List of priority areas

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Please note that for the UKRI AI CDT call, the major focus of the Centre should be one (or both) of the AI priority areas detailed within this document. Taking account of the EPSRC CDT call that is also underway, applicants may, if they wish, take account of the priority areas described in that call provided that they are a minor component of the proposal. Details of those priority areas can be found here: [https://epsrc.ukri.org/funding/calls/cdts2018full/]
1. Applications and Implications of Artificial Intelligence

Applications for Centres of Doctoral Training are open across the seven Research Councils (AHRC, BBSRC, EPSRC, ESRC, MRC, NERC and STFC), which address research into the Applications and Implications of Artificial Intelligence (AIAI). UKRI expects that AI will transform every sector of industry over the coming years and we want to ensure the UK is best placed to benefit. Innovate UK is also involved in this activity; co-creation between different disciplines and engagement with industry and users are strongly encouraged. Whilst high-quality proposals in any relevant area of the Councils’ remits are welcome, interdisciplinary proposals reaching across the remits of two or more Councils are particularly welcome.

Investing in CDTs in this area will train people across a spectrum from those with a background in AI wishing to apply their skills to a wide range of disciplines and challenges, to those who are from different disciplinary backgrounds, where AI could make a transformational contribution to that discipline or where that discipline could be brought to bear on the development of AI technology and approaches. CDTs should also consider the implications of applying their development and application of AI into the intended domains, examining the legal, ethical and socio-economic consequences of potentially disruptive intelligent technologies before they are deployed. Proposals for CDTs focused primarily on the legal, ethical or socio-economic implications of applying AI are also welcome.

In the recent Industrial Strategy White Paper [https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future] the Government laid out a Grand Challenge in ‘Growing the AI and Data-Driven Economy’, building on the groundwork laid by the Royal Society’s 2017 report ‘Machine Learning: the power and promise of computers that learn by example’ [https://royalsociety.org/news/2017/04/machine-learning-requires-careful-stewardship-says-royal-society/] and the independent review ‘Growing the artificial intelligence industry in the UK’ [https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk] carried out by Professor Dame Wendy Hall and Jérôme Pesenti published in October 2017. AI represents a new industry in its own right but it will also transform businesses across multiple sectors and affect how humans interact with each other and their environment. The UK already has globally recognised capability in the research that underpins AI. However, meeting this Grand Challenge means maximising the opportunities created by AI, as well as defining and responding to the possible implications on society this technology could cause.

Each application domain of AI will have its own challenges to deployment. For example, the barriers to adoption of AI in the health sector will be different to those for the automotive sector, will be different to those making decisions on supply chain risk. Therefore it is essential that bids to this priority consider the unique and specific implications for their domain.
Examples of the applications of AI include, but are not limited to:

**Biological, health and clinical sciences**
The biological, health and clinical sciences provide a wealth of opportunities and challenges that are potentially tractable through innovative use of AI and related approaches. Across the life sciences, data from high-throughput DNA sequencing and other ‘omics technologies, bio- and medical imaging across a range of different scales, automated phenotyping and sensor platforms, healthcare records, population level data and other sources of ‘big data’ present an unprecedented resource for data-driven research. Within the biosciences, AI will provide new ways to explore the fundamental properties and dynamics of biological systems, such as cell and physiological systems, as well as to address key challenges in the bioeconomy; for example, enabling laboratories of the future in synthetic biology and other bio-based industries, and delivering a step change in the agri-food sector by supporting automated decision making in precision agriculture, creating insight into animal and plant health issues, and identifying new ways to enhance sustainability. AI will enable automation, quantitation and enhanced reproducibility of analyses extracting information from ambiguous, noisy datasets, such as imaging, with greater sensitivity, potentially marker-free, and with higher throughput enabling the understanding of dynamic biological systems. In the health sciences, AI applications include digital pathology and radiology, acceleration of drug discovery research and development, systems medicine, biomedical informatics, improvements to diagnosis and support for clinical decision making or improving organisation of complex public health services and systems.

**Natural environmental sciences**
AI technologies have significant potential application across the breadth of environmental science remit. The skills of the environmental science community to effectively use AI approaches in managing, manipulating and interrogating big data for complex analysis and decision-making at increased spatial resolution and in real-time represents a step-change in potential understanding of the anthropogenic impact on the environment, as well as the impact of the environment on operating context of the human population and economy. The next generation of environmental scientists will require a broad skill base that combines both development and implementation of innovative environmental monitoring techniques with the necessary mathematical, computational and data management skills to apply AI techniques to environmental challenges. Examples of thematic challenge and application areas could include climate and weather modelling and visualisation, real-time analysis of complex natural systems, environmental genomics, water, supply chain risk and impacts, risk and hazard management, resilience and earth observation.

**Data from large science facilities**
Advanced data handling techniques employing AI will be crucial for dealing with the high complexity, rate and volume of data produced by the current and forthcoming generation of large science facilities. These include the UK’s large national facilities such as the Hartree Centre for the HPC and big data needs of UK industry; the Diamond Light Source, ISIS Neutron and Muon Source, and the Central Laser Facility for the physical and life sciences; and international ground and space facilities such as CERN, DUNE, ESO, SKA, LIGO, Planck, Gaia and LSST which produce experimental data on an unprecedented scale in areas including astronomy, particle physics and nuclear physics. AI techniques will be both developed and used to transform how these huge data sets, from national
and international facilities, are analysed and understood, with enormous implications ranging from pattern recognition and front-end data reduction to novel data-driven reconstruction, analysis and discovery.

**Creative industries**
The creative industries are a key part of the UK economy, estimated to be the fastest growing sector within the UK. Intelligent tools, platforms and technologies are increasingly being used to create, disseminate, redistribute, link and consume content and innovative ways to benefit society, enhance user experiences and support inclusion.

When addressing challenges in this area bids could look to providing meaningful new experiences within the creative industries using AI – for example, in popular entertainment, considering audiences of the future, community engagement, augmented reality, and within the heritage and cultural sectors. More broadly, a focus on how AI can enhance the creative arts as well as understand the impact of AI on those practices would be beneficial.

**Service Delivery**
AI offers the potential to transform the delivery of a wide range of services, from health and social care to financial services and other administrative functions.

Bids contributing to this area may wish to focus on the use of AI to assist: the improvement and personalisation of assessable public services; the provision of health and social care including the mental health implications and ethics of artificial intelligence-based systems as carers; civic engagement and participation; financial services and management; environmental and urban planning, as well as other administrative functions.

CDTs contributing to all the application areas described above must, where appropriate, demonstrate feasible access to relevant datasets at scale, required for the application of AI. They will involve the development and application of advanced AI methods to turn vast data streams into knowledge, understanding and physical action. Bids could also consider intelligent front-end data reduction, interpretation of information from smaller datasets, the validation of new AI methods and tools to help decision makers assess risk and uncertainty. CDTs funded through this priority could focus on one specific domain or develop generalised AI methods applicable to a variety of sectors.

Examples of the **implications of AI** include, but are not limited to:

**Law, regulation and intellectual property**
With the significant advances in AI and other technologies there is a clear and associated need for further research on the human impact of entering an age of AI and the consequent implications for law and justice.

Bids contributing to this area should consider industry standards, regulation and legislation in AI, both for those writing AI algorithms and for those using them.

**Impact of AI on workers, the economy and governance**
When looking at the potential broader socio-economic implications and consequences of AI, those undertaking the research need a clear understanding of what is possible and realistic in terms of technological advancement.
Bids contributing to this area should address the impact of AI on economic productivity, work patterns, monopolies and potential changes in business models. They should also consider the broader societal impacts and governance issues, such as the effects of changes in employment patterns and implications for security and the management of risk.

**Applied ethics**

It is necessary that AI systems are developed to relate to the needs of the people who use them; ensuring such systems are safe, secure, reliable, trustworthy, legally compliant and ethically sound.

Bids contributing to this area should address issues of trust, transparency, privacy, fairness and bias in the development and adoption of AI.

**Human-human and human-machine interactions**

To ensure that technology is useful and will work effectively in the real-world environment, researchers working in AI need to have a clear understanding of how humans will interact with the technology.

Bids contributing to this area should consider how AI technologies affect human-human interactions, such as bias outcomes and the identification and challenge of negative social attitudes. They should also consider how humans interact with AI machines, understanding how diverse communities interact with AI and the accessibility of products and services delivered through digital technologies. Research should also examine how users are able to interpret results, how trust in the outcomes from intelligent technologies is facilitated, and the impact on user training requirements.

All CDTs in the Applications and Implications of Artificial Intelligence priority area:

- Must specifically address and action Responsible Research and Innovation [https://www.epsrc.ac.uk/research/framework/] in the context of this area as part of the research and training agenda.
- Will have awareness and provision of training in cross-cutting issues which have relevance to a variety of domains (e.g. ethics of data science, healthcare regulation, accountability, bias)
- If required, should embed students in an environment with relevant domain expertise and/or an industrial sector to facilitate the rapid adoption and appropriate development of new AI technologies by engaging with the user base. This will help students to build up a picture of how research in different domains can have an impact beyond the academic community, and then to integrate this understanding into their own research.
- Bids should link to existing relevant national resources, infrastructure and investments; for example, the Hartree Centre and the Alan Turing Institute.

Applications are not expected to cover the full breadth of this priority as described. We expect to make multiple complementary investments in this area, subject to quality.
2. Enabling Intelligence

Investing in CDTs in this area will equip the UK with highly skilled people across the full spectrum of artificial intelligence (AI) technologies, to the benefit of society and the economy. This training will strengthen the UK in three key interacting areas of AI: fundamental research (e.g. decision-making, machine learning, interactive AI); cross-disciplinary approaches to technology development (e.g. embedding safety and security, cultural/societal/ethical considerations, natural language processing, machine vision); and technology applications (e.g. developing novel tools that enable non-specialists to use AI technologies to aid decision-making).

AI technologies offer huge potential to turn vast data streams into knowledge, understanding and physical action, and to revolutionise productivity. As well as delivering innovations such as driverless cars, they are increasingly being used to improve manufacturing productivity in sectors as diverse as aerospace, automotive, food and pharmaceuticals. Areas of application also include healthcare, high-value data-driven service sectors such as insurance and advertising, and the automation of scientific discovery. Driving forward fundamental research, exploring real-use cases and tackling key issues such as bias, safety, security, trust, inclusivity, privacy, and transparency will release the potential and build societal confidence in AI. This demands a cross-disciplinary whole-systems approach spanning engineering and physical sciences, life sciences, economics, law, ethics and other areas.

CDTs in this area:

- Must specifically address and action Responsible Research and Innovation [https://epsrc.ukri.org/research/framework/] in the context of this area as part of the research and training agenda. Including aspects such as, the need for safety and security in the field of intelligent software and systems development, and the need for ethics in design and knowledge of the regulatory environment.

- Should deliver multidisciplinary taught programmes that reach beyond core computer science and include consideration of the wide-ranging applicability of intelligent technologies.

- Should encourage students to engage with industry and with users of AI technologies. This will help students to build up a picture of how research in this area can have an impact beyond the academic community, and then to integrate this understanding into their own research.