Artificial Intelligence Hubs for Real Data

Link to funding opportunity

Summary of Successful Outline Proposals (Ordered by grant number)

Grant No.	PI	Title
EP/Y006739/1	Professor Seth Bullock	AI for Collective Intelligence Hub
EP/Y007131/1	Professor Clive Roberts	AI for Future Transport Hub
EP/Y007190/1	Professor Arnold Beckmann	Neuro-Symbolic AI Revolution (NeSyAIR)
EP/Y007298/1	Professor Serge Guillas	New AI-guided Earth Simulations (NewAGE): leading-edge Uncertainty Quantification of complex computer models
EP/Y007344/1	Professor David Barber	AI Hub in Generative Models
EP/Y00759X/1	Professor Sotirios Tsaftaris	CHAI - EPSRC AI Hub for Causality in Healthcare AI with Real Data
EP/Y007697/1	Professor Rajiv Ranjan	National Edge AI Hub for Real Data: Edge Intelligence for Cyber-disturbances and Data Quality
EP/Y007832/1	Professor Anahid Basiri	AI Hub for Real Data: Intelligence from New Forms Of data (INFO Hub)
EP/Y007840/1	Professor Klaus McDonald-Maier	Real-time AI with Dynamic and Robotic Systems for Industrial and Societal Impact
EP/Y007891/1	Professor Nasir Rajpoot	The CoDa of Complex Data
EP/Y007964/1	Professor Jean-Baptiste Cazier	Building AI Communities For Real WorlD Knowledge ImplEmentation In Health & Social Care

Grant Reference Number: EP/Y006739/1

Title: AI for Collective Intelligence Hub

Team:

- Professor Seth Bullock, University of Bristol (PI)
- Dr Aisling O'Kane, University of Bristol
- Dr Laura Smith, University of Bath
- Professor Hywel Williams, University of Exeter
- Professor Phillip Morgan, Cardiff University

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Brief description of proposed work:

AI and Machine Learning often address challenges that are relatively monolithic in nature: determine the safest route for an autonomous car; translate a document from English to French; analyse a medical image to detect a cancer; answer questions about a difficult topic. These kinds of challenge are very important and worthwhile targets for AI research.

However, an alternative set of challenges exist that are more *collective* in nature and that unfold in *real time*:

- help coordinate an ongoing national vaccination programme in order to minimise the impact of a pandemic sweeping through a population of people;

- predict and then monitor the extent and severity of an extreme weather event using multiple real-time physical and social data streams;

- anticipate and prevent a stock market crash caused by the interaction between many automated trading agents each following its own trading algorithm;

- assist populations of people with type ii diabetes (and their carers and clinicians) to make good decisions about managing their condition in order to avoid acute episodes that may result in hospitalisation, by identifying patterns in their pooled experiences while preserving their privacy and anonymity.

Developing AI systems for these types of problem presents unique challenges: extracting reliable and informative patterns from multiple overlapping and interacting data streams; determining the local interventions that can allow smart agents to influence collective systems in a positive way; developing privacy preserving machine learning and advancing ethical best practices for collective AI; embedding novel machine learning and AI in portals, devices and tools that can be used transparently and successfully by different types of user.

The AI for Collective Intelligence (AI4CI) Hub will address these challenges for AI in the context of critically important real world use cases (initially: pandemics, health care, environment and finance) working with key stakeholder partners from each sector.

In addition to significantly advancing applied AI research for collective intelligence, the AI4CI Hub will also work to build *community* in this research area, linking together academic research groups across the UK with each other and with key industry, government and public sector organisations, and to build *capability* by developing and releasing open access training materials, tools, demonstrator systems and best practice guidance, and by supporting the career development of early and mid-career researchers both within academia and beyond.

The AI for Collective Intelligence Hub will be a centre of gravity for a nation-wide research effort applying new AI to collective systems.

Grant Reference Number: EP/Y007131/1

Title: AI for Future Transport Hub

Team:

- Professor Clive Roberts, University of Birmingham (PI)
- Dr Benedict Waterson, University of Southampton
- Dr Charisma Choudhury, University of Leeds
- Dr Enrico Gerding, University of Southampton
- Dr John Easton, University of Birmingham
- Dr Marc de Kamps, University of Leeds
- Dr Mark Lee, University of Birmingham
- Dr Simon Blainey, University of Southampton
- Dr Thomas Jansen, Aberystwyth University
- Professor Anthony Cohn, University of Leeds
- Professor Ed Manley, University of Leeds
- Professor Fern Elsdon-Baker, University of Birmingham
- Professor Jonathan Preston, University of Southampton
- Professor Qiang Shen, Aberystwyth University
- Professor Reyer Zwiggelaar, Aberystwyth University
- Professor Ronghui Liu, University of Leeds
- Professor Samia Nefti-Meziani, University of Birmingham
- Professor Tom Cherrett, University of Southampton

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Brief description of proposed work:

The vision for the AI for Future Transport Hub is to bring together the AI and data science communities with experts and problem-holders in the transport sector to identify, accelerate and achieve the implementation and deployment of AI-based solutions that support seamless passenger and freight movements.

There is huge potential for AI to be applied to real-time and dynamic transport data sets to address the Department for Transport's key research challenges of: (i) Improving transport for the user (putting users at the heart, utilising emerging technology; safe, secure, resilient transport; muti-modal active travel; demand based transportation); (ii) Reducing environmental impacts (using technological innovations; accelerating and scaling solutions; encouraging behavioural change); (iii) Growing and levelling up (traveller confidence; incentives; increased investment); (iv) Global opportunities (sharing international metrics to measure performance and effectiveness). Key workstreams within the hub will consider how users are engaged and appropriate governance (including data security) is created to ensure that solutions are fit for purpose, robust and scalable. The challenges and opportunities addressed within the hub will primarily focus on multi-modal, active travel as part of a future demand-based transport system. Transitioning to demand-based transport is a key objective of the UK Department for Transport and governments around the world. This transition is wholly dependent on a comprehensive understanding of AI-driven, dynamic data exploration and optimisation approaches. Identified through stakeholder challenge statements, projects within the hub will be driven by the operational needs and/or strategic/policy demands of the sector.

Grant Reference Number: EP/Y007190/1

Title: Neuro-Symbolic AI Revolution (NeSyAIR)

Team:

- Professor Arnold Beckmann, Swansea University (PI)
- Dr Ekaterina Komendantskaya, Heriot-Watt University
- Dr Francesco Belardinelli, Imperial College London
- Dr Vaishak Belle, University of Edinburgh
- Professor Michael Fisher, The University of Manchester

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Brief description of proposed work:

The large-scale uptake of AI has been driven by advances in Connectionist AI like data intensive Machine Learning. While these approaches are very powerful, they lack the transparency, explainability and verifiability provided by Symbolic AI, like logic-based approaches as in expert systems. Symbolic AI in turn does not match the performance and scalability of Connectionist AI. Progress in addressing the limitations of both approaches has been slow: incremental steps from pure Connectionist AI have only provided very limited advances in terms of transparency, explainability and verifiability; incremental steps from pure Symbolic AI have not shown significant efficiency increases.

We propose a fundamental shift to considering the Connectionist AI and Symbolic AI aspects of future Neuro-Symbolic systems as being equally important, equally contributing to overall benefits. Inspired by recent results, we see Neuro-Symbolic methods to form a new level of abstraction for the design and implementation of intelligent systems, to enable any possible integration of Machine Learning and Symbolic AI. Our cross-disciplinary research framework will build on this fundamental view, while taking advantage of developments in the individual fields. NeSyAIR proposes an extensive Neuro-Symbolic hybrid AI suite, ranging from combinations of Connectionist AI and Symbolic AI components, to tightly linked Neuro-Symbolic tools.

Grant Reference Number: EP/Y007298/1

Title: New AI-guided Earth Simulations (NewAGE): leading-edge Uncertainty Quantification of complex computer models

Team:

- Professor Serge Guillas, University College London (PI)
- Professor Daniel Williamson, University of Exeter
- Professor Iain Styles, University of Birmingham
- Professor Kenneth Carslaw, University of Leeds
- Professor Philip Stier, University of Oxford
- Professor Sarah Dance, University of Reading

Brief description of proposed work:

Met Office weather forecasts and warnings must be precise in order to evacuate from floods or prepare for storms. Future climate must be well predicted in order to take relevant actions against climate change, where the key is enabling future-proofing e.g. working out what temperatures new infrastructure (like roads, rail, suspension bridges) need to be robust to, when/whether current flood defences need to be upgraded, whether locations for nuclear power stations are too close to the coast to withstand future storm surges. Air pollution must be well modelled as it affects human health, and thus measures must be taken to manage traffic or improve standards of polluting industrial processes. However, the uncertainties in these studies can be huge, with larger and more complex data and ever more sophisticated computer models. These challenges reduce the ability to make the right decisions. Hence we must investigate how to improve the assessment of uncertainties for such advanced problems.

AI and Machine Learning (ML) offer enormous opportunities to quantify and reduce uncertainties in these settings. So the Met Office and six Universities formed the AI Hub called New AI-guided Earth Simulations (NewAGE) to create AI techniques and apply them to real data in weather, climate and air pollution to provide a step-change in the quality of the modelling of uncertainties in this area. NewAGE consists of leading institutions with expertise across AI and weather and climate sciences and will develop methods that will help with the next-generation modelling in this area, and beyond across science/engineering simulations.

NewAGE will enable better modelling of imperfect simulations of climate change, such as the variations in time and space of precipitation to assess better future risk of flooding. It will allow many users of meteorological and climate information to take action and mitigate impacts. Technical challenges are speed and scalability, complex workflows, real-time data, big data and confidence in the outputs. Tools, techniques and approaches will be honed against real data from earth system modelling where these technical challenges are most pronounced. Once proved in this context they will be invaluable in many others in other sciences and in engineering.

Grant Reference Number: EP/Y007344/1

Title: AI Hub in Generative Models

Team:

- Professor David Barber, University College London (PI)
- Dr Jose Miguel Hernandez Lobato, University of Cambridge
- Dr Mark van der Wilk, Imperial College London
- Dr Michael Gutmann, University of Edinburgh
- Dr Oisin Mac Aodha, University of Edinburgh
- Dr Pontus Stenetorp, University College London
- Dr Yuhua Li, Cardiff University
- Professor Aldo Faisal, Imperial College London
- Professor Arthur Gretton, University College London
- Professor Chris Williams, University of Edinburgh
- Professor Jack Stilgoe, University College London
- Professor Lourdes Agapito, University College London
- Professor Magnus Rattray, The University of Manchester
- Professor Mark Girolami, University of Cambridge
- Professor Michael Wooldridge, University of Oxford
- Professor Miguel Rodrigues, University College London
- Professor Samuel Kaski, The University of Manchester
- Professor Yarin Gal, University of Oxford
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Brief description of proposed work:

Generative Models are AI models that can generate data. Recently researchers have shown that by training these models on large amounts of data (text data from the internet and images) these models learn to understand the regularities of our text and image world so well that they can generate responses to questions and create new images with surprising fidelity. This heralds a new era in which computers can assist humans to carry out tasks more efficiently than ever with significant opportunities for society, science and industry. However, these advances need significant research still -- how to make them train efficiently on different problems, how to understand their reliability and adherence to ethical norms.

Grant Reference Number: EP/Y00759X/1

Title: CHAI - EPSRC AI Hub for Causality in Healthcare AI with Real Data

Team:

- Professor Sotirios Tsaftaris, University of Edinburgh (PI)
- Dr Hana Chockler, King's College London
- Dr Matthew Sperrin, The University of Manchester
- Professor Ben Glocker, Imperial College London
- Professor Ricardo Silva, University College London
- Professor Sabina Leonelli, University of Exeter

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Brief description of proposed work:

The current AI paradigm at best reveals correlations between model input and output variables. This falls short to address health and healthcare challenges where definitive causal relationships between interventions and outcomes are necessary and desirable. In addition, biases and vulnerability in AI systems arise, as models may pick up unwanted, spurious correlations from historic data, resulting in the amplification of already existing health inequalities.

Causal AI is the key to unlock robust, responsible and trustworthy AI and transform challenging tasks such as early prediction, diagnosis and prevention of disease.

The Causality in Healthcare AI with Real Data (CHAI) Hub will bring together academia, industry, healthcare, and policy stakeholders to co-create the next-generation, world-leading artificial intelligence solutions that can predict outcomes of interventions and prescribe personalised treatments, thus transforming health and healthcare. The CHAI Hub will develop novel methods to identify and account for causal relationships in complex data. The Hub will be built by the community for the community, amassing experts and stakeholders from across the UK to

1) push the boundaries of AI innovation;

2) develop cutting-edge solutions that drive desperately needed efficiency in resource-constrained healthcare systems; and

3) cement the UK's standing as a next-gen AI superpower.

The data complexity in heterogeneous and distributed environments such as healthcare exacerbates the risks of bias and vulnerability and introduces additional challenges that must be addressed. Modern clinical investigations need to mix structured and unstructured data sources (e.g. patient health records, and medical imaging exams) which current AI cannot integrate effectively. These gaps in current AI technology must be addressed in order to develop algorithms that can help to better understand disease mechanisms, predict outcomes and estimate the effects of treatments. This is important if we want to ensure the safe and responsible use of AI in personalised decision making.

Causal AI has the potential to unearth novel insights from observational data, formalise treatment effects, assess outcome likelihood, and estimate 'what-if' scenarios. Incorporating causal principles is critical for delivering on the National AI Strategy to ensure that AI is technically and clinically safe, transparent, fair and explainable.

The CHAI Hub will be formed by a founding consortium of powerhouses in AI, healthcare, and data science throughout the UK in a hub-spoke model with geographic reach and diversity. The hub will be based in Edinburgh's Bayes Centre (leveraging world-class expertise in AI, data-driven innovation in health applications,

a robust health data ecosystem, entrepreneurship, and translation). Regional spokes will be in Manchester (expertise in both methods and translation of AI through the Institute for Data Science and AI, and Pankhurst Institute), London (hosted at KCL, representing also UCL and Imperial, leveraging London's rapidly growing AI ecosystem) and Exeter (leveraging strengths in philosophy of causal inference and ethics of AI).

The hub will develop a UK-wide multidisciplinary network for causal AI. Through extended collaborations with industry, policymakers and other stakeholders, we will expand the hub to deliver next-gen causal AI where it is needed most. We will work together to co-create, moving beyond co-ideation and co-design, to co-implementation, and co-evaluation where appropriate to ensure fit-for-purpose solutions.

Our programme will be flexible, will embed responsible innovation and environmental sustainability considerations, and will ensure that knowledge generated through CHAI will continue to have real-world impact beyond the initial 60 months.

Grant Reference Number: EP/Y007697/1

Title: National Edge AI Hub for Real Data: Edge Intelligence for Cyber-disturbances and Data Quality

Team:

- Professor Rajiv Ranjan, Newcastle University (PI)
- Dr Blesson Varghese, University of St Andrews
- Dr Peter Garraghan, Lancaster University
- Professor Hui Wang, Queen's University of Belfast
- Professor Liana Cipcigan, Cardiff University
- Professor Sarvapali Ramchurn, University of Southampton

Brief description of proposed work:

This Hub will address two key challenges introduced by the use of Edge Computing (EC) to support emerging AI algorithms: (i) dealing with "cyber disturbances"; (ii) managing data quality. This Hub will achieve these through a unique 2x3x3 matrix that reflects the complexity of these systems through two real-world application domains, three tiers of EC architectures, and three ground-breaking research work strands. It examines the relationships between them through a multi-disciplinary team from universities distributed across the UK. Team members have a strong record in EC architecture (Newcastle, Cardiff, St. Andrews, UWS), foundational AI and Data Quality (Southampton, Durham, QUB, Swansea), wireless communication (Cardiff, UWS), device malfunction/attack detection and prevention (Newcastle, Lan-caster, Cardiff), and AI security (Lancaster, Swansea, Durham). This combination of partners will enable us to engage with regional development agencies within these areas of the UK.

Applications include Autonomous Electric Vehicles and Remote Healthcare, using the Urban Observatory test-bed, an internationally leading UK-funded effort collaborating with sensor system manufacturers, software companies and stakeholders. We will utilise interactions across three tiers of EC architectures: sensors (Tier 1), edge devices (Tier 2) that control these sensors and cloud-based (Tier 3) data storage & processing, identifying the benefit of using these interactions to support real-world data processing. Research activities are under four interrelated strands - which constitute an ambitious research agenda.

Engagement with Education: The Hub will contribute content to undergraduate and post-graduate courses (such as MSc programs in Big Data, AI and Cybersecurity), and Centres for Doctoral Training and industry training events. These will include research webinars/ seminars and educational events linked to major international conferences (such as IEEE/ACM CCGrid). The application use cases will also provide case studies within such courses/ training events, and enable engagement with the wider user community. The proposed innovations in education and workforce development will also enable all Hub members to improve their ethical AI awareness and competence, to better promote and be conscious of equity and fairness in AI research. The two applications being considered are particularly impacted by these considerations.

Research Community Engagement: We will liaise with other AI Hubs to maximise cross-Hub communication and engage with all sectors of the AI research and innovation community to strengthen impact. We will share the results of our findings across academia & industry in the UK and internationally. Our outreach programme will consist of symposiums, (online and face2face) and more focused interactions to maximise impact.

Outputs: these will include innovative scientific publications in high-impact venues and invited lectures. To expand our outreach, we will organise workshops at major conferences, such as IJCAI, AAAI, EuroSys, and ICRA. Software/Data Outputs: we will disseminate research-based software and datasets produced by this Hub in public repositories and online to increase access and awareness. Standards Contribution: we will proactively present our research at invited meetings of standards bodies, such as the International Telecommunications Union (ITU-T) and European Telecommunication Standardization Institute (ETSI) with a focus on Edge systems, 6G and beyond, and AI innovations. Collaborative Projects: Hub partners will act as a liaison with existing EPSRC and EU projects: such as the Scalable Circular Supply Chains, the TAS-S: Trustworthy Autonomous Systems Node in Security project, the EU Horizon 6G-IA Phase 1 RIGOUROUS project, and the

EU INCODE project, to create synergies, maximize impact and allow cross-project collaboration. inviting them to present their research in formal events and workshops.

Grant Reference Number: EP/Y007832/1

Title: AI Hub for Real Data: Intelligence from New Forms Of data (INFO Hub)

Team:

- Professor Anahid Basiri, University of Glasgow (PI)
- Dr Robin Mitra, University College London
- Dr Stuart Middleton, University of Southampton
- Mr Owen Abbott, Office for National Statistics
- Ms Charlotte Wroth-Smith, Office for National Statistics
- Professor Alex Singleton, University of Liverpool
- Professor Alexis Comber, University of Leeds
- Professor Daniel Arribas-Bel, University of Liverpool
- Professor David Hand, Imperial College London
- Professor James Cheshire, University College London
- Professor Muffy Calder, University of Glasgow
- Professor Natalie Shlomo, The University of Manchester
- Professor Nick Bailey, University of Glasgow
- Professor Nick Malleson, University of Leeds
- Professor Paul Longley, University College London
- Professor Roderick Murray-Smith, University of Glasgow
- Professor Sir Bernard Silverman, University of Oxford

Brief description of proposed work:

AI Hub in Intelligence from New Forms of Data (INFO-Hub) brings together world-leading experts across disciplines and sectors to harvest, manage and curate "new forms of data" that are real-time, dynamic and complex in nature for the widest range of policy applications. INFO-Hub will deliver novel AI methods and analytical solutions and showcase the effective use of non-standard data sources (potentially in conjunction with traditional data) to maximise benefits and deliver a (near) real-time understanding of cities, society, and complex systems. Thus, we will address the host of important current challenges we are faced with, including those in safety of society, public health, climate, and dynamic social statistics, as well as be better prepared for future ones.

"New Forms of Data", such as administrative records, commercial transactions, readings of ubiquitous sensors embedded in smart phones and watches, are the by-product of digitised lives, which can provide us with readily available data sources to exploit, typically at a high spatially and temporally granularity, and at near-population sizes, at a lower cost. These have provided us with an unprecedented opportunity to understand society, the economy, health, and the physical world at a much higher frequency than traditional surveys and sampled data. However, these are usually obtained with uncontrolled recording mechanisms, e.g. contributed voluntarily, presenting challenges around over/under-representation, biases, missingness, sparsity, and latent dependencies. This inhibits these sources being integrated effectively with traditional data sources to build a richer, more comprehensive, resource to build and train the latest statistical and cutting-edge deep learning AI models.

This hub will develop novel AI models and frameworks to consider missing data as useful data. This provides the foundational basis for combining traditional data with "new forms of data" to maximise the opportunities of having a real-time understanding of people, cities, and societies, which the key for timely decisions and policies in the fast-changing world around us. This will also lead towards more inclusive and equitable AI.

The ethics, reliability, liability, and accountability aspects of solutions can open conversation and research in better understanding human decision processes for the trade-offs of data sharing (e.g. privacy, agency, safety, and benefits). Ethics of "data we do not have", why, who, and how some groups are under/over-represented can enable AI models to take these into account during training and inference. Through foundational AI

research, we will improve the capacity of current state-of-the-art statistical and deep learning AI models trained with complex aggregations of new forms of data. Considering missingness and biases as useful data, enables the use of both available and unavailable data to compensate for the missing data. This will ultimately make the unheard more visible and deliver inclusive AI.

The foundational statistics and deep learning AI models of the hub can be applied to a wide range of applications and disciplines, including policing (e.g. under-reported crime, hidden online harms), social care, public health, inclusive city planning, and of course, aligned with Office for National Statistics (ONS) strategy, the dynamic census. Reliable social statistics from new forms of data will be the (first) application area that will be delivered by this hub to demonstrate the applicability of the general foundational work.

The ecosystem of the hub (with Co-Is from 13 UK Universities, and ONS (the UK Statistics Authority), advisors and partners from the UK and Scottish Government (including six Departments and units), technology companies (including Google and Meta), as well as international leading scientists (including Hardvard Data Science Initiatives) closely with key stakeholders and end-users to shape and expand the research agenda.

Grant Reference Number: EP/Y007840/1

Title: Real-time AI with Dynamic and Robotic Systems for Industrial and Societal Impact

Team:

- Professor Klaus McDonald-Maier, University of Essex (PI)
- Dr Amir Masoud Ghalamzan Esfahani, University of Lincoln
- Professor Maria Fasli, University of Essex
- Professor Rustam Stolkin, University of Birmingham
- Professor Sarvapali Ramchurn, University of Southampton
- Professor Stephen Pierce, University of Strathclyde

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Brief description of proposed work:

MOSAIC addresses UKRI's call for a nationwide consortium to develop a body of new AI methods, to handle the complexities of: real-world data for real-time and dynamic systems.

We will achieve rapid societal and economic impact, by demonstrating core advances in AI fundamentals that deliver a new generation of smart robotics solutions for industry. Such systems are ideal platforms for: i) highlighting challenges of real-time and dynamic data; ii) demonstrating AI advances in real applications.

These dynamic systems, in unstructured real-world environments, engender complex AI research challenges: massive data flows from high-bandwidth, distributed, multi-modal sensors; feeding perception, planning and control algorithms; linked to real-time digital twins encoding dynamics and uncertainty; connected by dynamically reconfigurable communications networks, to hard-real-time machinery.

UK is one of the most under-roboticized industrial nations, with only 70 robots per 10,000 employees (300 in Germany, 700 in Korea). MOSAIC targets strategic industries which remain labour-intensive: agriculture; healthcare; manufacturing; nuclear decommissioning; waste handling and recycling; construction; infrastructure; logistics. Brexit and COVID accelerated UK labour shortages, and many such working environments are hazardous, harsh or unpleasant tasks.

We deliberately choose to address challenges in a wide diversity of industries. This is to demonstrate that our core AI advances are fundamental, i.e. generic, generalisable methods and technologies, usable in many different applications. We also leverage our CoI's leadership of several £multi-million UKRI investments in national robotics and AI hubs, centres, and infrastructure. Examples of industry challenges, where we already have strong end-user engagement for achieving rapid impact, include:

- Robots and sensors for extreme environments, including the nuclear sector where several member universities have long track records, and space (also a high radiation environment), where U Essex has many years collaboration with NASA.

- Construction and Infrastructure inspection - heavy-duty manipulators on construction sites require computer vision, sensing, navigation and autonomous motion control to operate in harsh unstructured environments, while soft/flexible robotic solutions are needed to enter inaccessible voids for inspection and to improve insulation. Both types of robot have highly non-linear dynamics demanding learning/AI approaches.

- Agriculture and Food Supply - require soft manipulators, advanced vision systems, and autonomous navigation systems to locate, recognise and pick ripe produce in the field in uncertain weather, and handle soft food products in automated large-scale groceries.

- Manufacturing - will draw on advanced vision systems, guiding complex manipulator trajectories, and autonomous grasping, for in-process robot-deployed NDT inspection of aerospace components, and flexible handling in SME manufacturing of small batches with frequent product changeovers.

- "Un-manufacturing" and the Circular Economy - application of RAI techniques will enable robotic disassembly needed to extract high-value, but hazardous, critical materials and components from extremely complex, multi-scale Electric Vehicle batteries at end-of-life, for re-use in a circular economy.

- Logistics, Warehouses, and Transport - automated, flexible systems able to navigate environments without GPS will provide scaleable systems for SME's for whom commercially-available large-scale warehouses are unsuitable.

- Surgery - the same AI-guided robotics principles can also be applied to key-hole surgery or the sub-mm movements in complex eye surgeries, combined with newly emerging real-time 3D eye imaging technologies. The soft manipulators of UCL and QMUL have large application in keyhole surgery, engendering complex demands on AI for perception and control.

Grant Reference Number: EP/Y007891/1

Title: The CoDa of Complex Data

Team:

- Professor Nasir Rajpoot, University of Warwick (PI)
- Dr Varuna De Silva, Loughborough University
- Professor Aad van Moorsel, University of Birmingham
- Professor Ashiq Anjum, University of Leicester
- Professor Elena Gaura, Coventry University
- Professor Theodore Kypraios, University of Nottingham

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Brief description of proposed work:

Artificial Intelligence (AI) is one of the most transformative technologies that has demonstrated its potential in several applications over the last few years. However, its potential is yet to be fully realised to deliver value in terms of societal and economic benefits. One reason for this is that most Real-World Applications (RWAs) that can benefit from AI (e.g., medicine and earth observation) have to deal with complex data but methods and techniques to create value from them are not adequately developed. By complex data, we often mean data that are noisy, incomplete, various types (e.g., text, images, numbers), distributed in availability and not organised in a defined format (or unstructured).

The proposed AI hub for the Coda of Complex Data (CODA-AI) will research and deliver robust, equitable and sustainable methods to address seven fundamental challenges associated with AI for complex data. The hub will address this significant problem by bringing together a diverse team of academics from 7 research-intensive universities in the Midlands region and over 30 external project partners from NHS, big pharma, sports technology, earth/space science & technology, finance, manufacturing, public bodies and big tech organisations. We will research and develop novel AI techniques to address key challenges associated with complex data for the following five RWA domains, to begin with: precision medicine, space science & technology, sports technology, energy device manufacturing and ethical finance. The hub will develop breakthrough complex data AI methods by promoting an organic interaction, knowledge sharing, and collaboration between AI experts, domain-specific experts and end users in the industry and public organisations through a bespoke co-creation approach, guided by the principles of and helping achieve the UN sustainable development goals.

The CODA-AI hub team will pioneer an innovative co-creation methodology that we term as the Sprint-to-Marathon Model, where several short-term "sprint" projects akin to Proof of Concept (POC) studies executed by cross-disciplinary teams are then followed by a smaller number of longer duration "marathon" projects covering the five RWA domains that offer the greatest potential. In particular, the hub will explore the commonality and variability of cross-scale and cross-RWA-domain complex data challenges to cater to diversity, equality and inclusivity needs, resulting in equitable, sustainable and transferrable AI techniques. The hub will produce shareable, transferable and reproducible AI solutions for handling complex data. This will be enabled partly through the identification and investigation of fundamental ground-breaking AI methods inspired by cross-domain and intra-domain collaborations facilitated by the Hub.

The hub will continuously share case studies, best Equality, Diversity & Inclusion (EDI) practices for responsible data and AI design and lessons learnt within/across domains with the project partners and end-users, and engage with the public and policy makers to enable sustainable change on AI practice and adoption of AI within industries. Towards leaving a long-lasting legacy, during the period of 5 years, the CODA-AI hub will engage, train and mentor a highly diverse network of individuals at all stages of their careers to develop the next generation of AI & domain experts with a strong multi-disciplinary understanding of complex data AI and allow highly skilled AI professionals to be embedded in real-world settings. The hub will lead to the forming of many new multi-disciplinary collaborations, leveraging on significant public and industrial funding through new grant applications for further scientific advances in the field of complex data AI. As a direct result of CODA-AI

and working in collaboration with our industrial partners and end-users, we expect scientific breakthroughs, patents and products that will help deliver real societal and economic benefits.

Grant Reference Number: EP/Y007964/1

Title: Building AI Communities For Real WorlD Knowledge ImplEmentation In Health & Social Care

Team:

- Professor Jean-Baptiste Cazier, University of Birmingham (PI)
- Professor Eiman Kanjo, Nottingham Trent University
- Professor Elizabeth Sapey, University of Birmingham
- Professor Peter Tino, University of Birmingham
- Professor Theodoros Arvanitis, University of Birmingham
- Professor Thomas Sorell, University of Warwick

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Brief description of proposed work:

Artificial Intelligence (AI) uses machines for complex tasks that humans may struggle to complete. The UK Government recognises that AI can transform health and social care and has made the development of health-based AI a key priority. Despite this, there remains little AI in health and care settings.

There are 3 key challenges:

A. AI is often developed in isolation, without end-users. This means the AI "idealised solutions" do not necessarily solve problems that practitioners feel are important or that work in their systems.

B. Researchers need access to many types of data when building AI solutions. However, data is often incomplete, collected by different systems and in different locations - bringing data together is complex.

C. There is a need for greater trust in AI. We need to ensure AI solutions reduce inequalities, are reproducible, acceptable, and fully evaluated before being deployed.

These challenges reflect our 3 priority themes:

Priority 1: Building sustainable AI together with stakeholder communities

Previously, we found that 99% of image based AI studies are poorly designed and their results were not widely used. Our Hub will bring together AI-experts with AI-stakeholders (regulators, health and social care practitioners and providers, the public and patients, policy makers, government departments and industry). Together, they will co-develop AI-based solutions for real-world health and social care challenges, focusing initially on use cases which have already been prioritised by regional health and social care providers, sharing the learning widely.

We will build the AI workforce of the future through training and mentorship. We will ensure that AI specialists work within multi-disciplinary teams, building a vibrant, cross-sector community of practice which is "future fit".

We will become a sustainable Hub through understanding our environmental impact and by understanding community and customer needs.

Priority 2: Building better data and methods

Machines, like humans, need to be trained. AI is trained using datasets. However, the datasets needed are often incomplete, contain noisy data, collected at pace, separated physically, and don't include data from all communities. New approaches and tools are needed to improve how we gather and use these "imperfect" real-world data streams, and developing these approaches and tools will be at the heart of the Hub.

We will address how to deal securely with incomplete and complex data (including images, measurements, location data), where data needs to be assessed quickly or where data is held in different locations. The close collaboration of the whole AI community (including end-users) will ensure the meaning, value and underlying structure of the real-world data is understood and used to benefit our population.

Priority 3: Building greater trust in AI

For people to trust AI, they need to know that it is safe and fair, especially in health or social care. For AI development, researchers need access to large volumes of sometimes sensitive personal data. Working with stakeholders, we will develop tools for decision-makers to help them determine if data access is safe and that AI interventions are effective and fair based on representative health data. We will also assess how AI algorithms are viewed and used by potential end-users, building steps which increase trust and utilisation into our research projects.

Impact:

By addressing these challenges through our priorities, this Hub will:

1. Develop new tools and approaches in AI, to make best use of the expanding data opportunities of the digitalised world and share this learning across sectors,

2. Build AI interventions in health and social care that are safe, accepted, effective, validated and inclusive,

3. Develop public, health and social care provider and regulator trust in AI

4. Help position the UK as a leader in AI for health and social care.