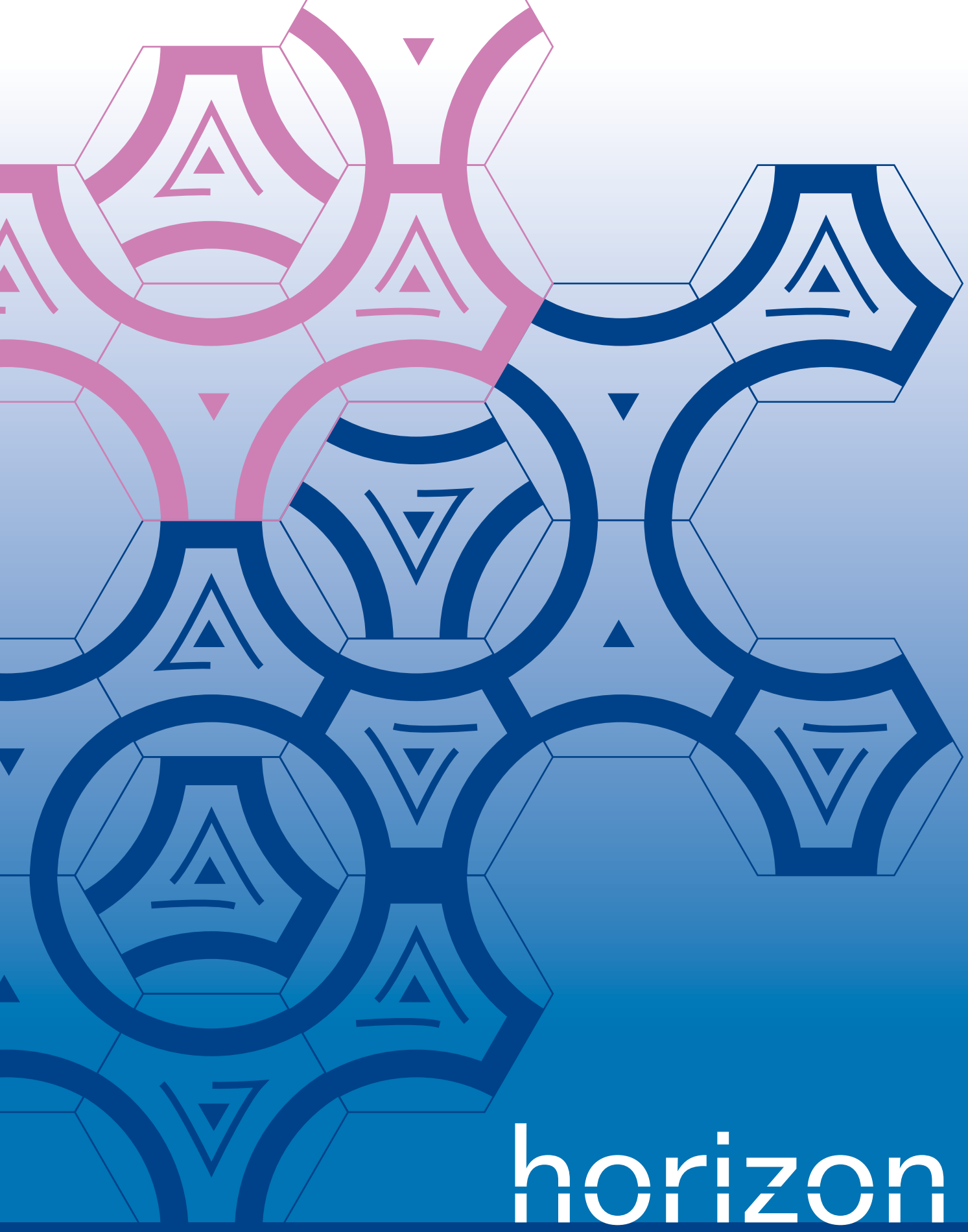


horizon

DIGITAL ECONOMY RESEARCH

Mid Term Review Impact Highlights

Contents

Foreword

Established in 2009 and centred at the University of Nottingham, the UKRI-funded Horizon Digital Economy Research Hub and Centre for Doctoral Training brought together a team with expertise spanning a wide variety of disciplines to address challenges in the Digital Economy. In partnership with academic colleagues from the Universities of Cambridge, Exeter, Newcastle, and the Royal College of Art, we carry out research 'in the wild', embedding our research in the practices of our external partners spread across a wide range of industry sectors, and engaging with regulators to inform policy.

The last decade has seen an explosion in the capabilities of the internet. The exponential growth in internet use, along with the rapid uptake of smart digital technologies by society, has resulted in huge impact on our everyday lives – transforming the way we live and influencing how business operates.

In this digital era where automated algorithm-driven online platforms underpin many of our services, the sharing, collection, analysis and processing of personal data is prevalent. We are working with a wide range of stakeholders to introduce novel technologies and practices to address the challenges of ethics, privacy, security, trustworthiness and fairness in our use of these "smart" technologies.

We also have a responsibility to society in general to engage with decision makers who set goals, make rules and prepare guidelines. This involves working within the policy arena as independent experts in order to present the most up-to-date research insights, encourage policy debate and inform regulation.

The training of interdisciplinary researchers has also been a key mission. By enabling cross-disciplinary communication and understanding, we have helped develop future research leaders needed to address the continuing challenges in the digital economy.

Professor Derek McAuley

Horizon impact

OUR journey

2017

April

UnBias submits evidence to Fake News and Algorithms in Decision Making UK Parliamentary inquiries

May

Thresholds tours to Somerset House

June

Databox introduced to industry at BT Innovation Week

September

Horizon leads Internet of Things workshop in Japan on behalf of EPSRC

October

VR Playground at PyeongChang Winter Olympics, Seoul, South Korea

2018

May

UnBias at Polka Techtopia Festival and animation video launch 'Our Future Internet: Free and Fair for All'

June

UnBias submits evidence to ICO call for 'Age Appropriate Design Code'

July

The Royal College of Physicians 'Safe Medical Staffing' report is launched referencing Wayward

Panopticon deployment at National Videogame Museum

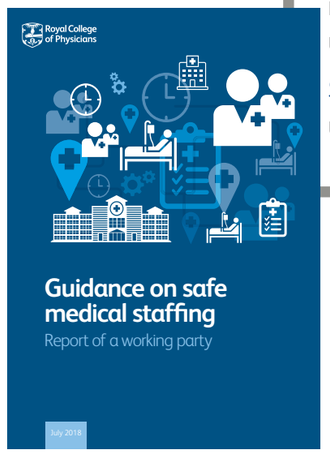
August

Databox launches 0.5.0 version

UnBias launches 'Fairness Toolkit'

September

UnBias and Databox at V&A Digital Design Weekend



2019

January

The MOMENT tours to SPARK Festival, Hong Kong

February

UnBias at Festival of Science, Horizon CDT receives third round of EPSRC funding

March

Unlocking digital competition – Report of the Digital Competition Expert Panel published

Andy Crabtree updates us on Databox, an open source networked device that enables individuals to exercise greater control over their personal data, particularly data generated in a consumer-oriented Internet of Things.

The 'Internet of Things' or IoT is the network of physical devices, home appliances, vehicles, and other everyday objects in which electronics, software, sensors and actuators connect to the internet and collect and exchange data. The IoT is driving the widespread development and delivery of 'smart' and 'personalised' consumer services. However, it is not without its problems.

"The sheer scale of different types and amounts of data able to not just be collected, but aggregated and merged with other data, poses a much magnified risk to privacy than in pre-Internet of Things scenarios."[1]

Databox tackles the risk to privacy head-on. Approaching its final year of EPSRC funding, the Databox project introduces a very different approach to present practice, in which data is collected and transferred to computers in 'the cloud' for processing. In contrast, Databox takes the computing to the edge of the network in the consumer's home. Instead of shipping raw data – much of which is not actually required to deliver a smart, personalised service – Databox does the processing locally and only ships the results needed to deliver a service, if anything need be shipped at all. Databox massively reduces the amount of personal data that is distributed by the IoT, thereby enabling a radical degree of 'data minimisation' in keeping with the most recent privacy legislation[2]. It also empowers individuals by providing a familiar app-based environment that makes data processing transparent and accountable to users and allows them to exercise control over who and what can access their data.

Databox is key to building trust between service providers and individuals by enabling the development of smart services where 'your data never leaves your house.' At the same time we have been fostering an open source community through dedicated Databox 'hack' events and participation in leading privacy forums including the annual Mozilla Festival, which have attracted several hundred developers to 'get their hands on' the Databox platform. These efforts are complemented by the creation of a dedicated Databox development environment, supporting rapid application development while enabling data protection by design and default. It has also attracted strong interest from the software industry, for example, DT42 – a technology company focusing on Artificial Intelligence and deep learning – which seeks to incorporate the Databox platform in its 'smart brain for IoT devices', BerryNet.

Leveraging my EPSRC Fellowship 'Privacy-by-Design', we have engaged the developer community through industry involvement and collaboration, demonstrating the Databox approach at British Telecoms' flagship Innovation Showcase to over 5000 of its largest customers and key decision-makers as part of its 2017 'Smart World' vision. Building on prior collaboration with BBC Research & Development on the 'Kitchen demo', which focused on the potential relationship between the IoT and media experiences – demonstrated at Mozfest in 2016 – we co-created the Living Room of the Future (LRoTF), to showcase future immersive media experiences exploiting the IoT and users' data in privacy-preserving ways. The LRoTF was deployed at the Foundation for Art and Creative Technologies and the V&A's Digital Design Weekend in 2018. We are currently collaborating with the BBC to provide a demonstrator of a future personal data platform for widespread organisational uptake and use called the 'BBC Box', while exploring the potential use of Databox in vehicles with Audi.

The Living Room of the Future is the centre-piece of a newly funded Digital Economy Investigator-led project called 'Experiencing the Future Mundane', which explores the development of an innovative design methodology for researching the adoption challenges of future and emerging technologies, including an increasingly 'intelligent' Internet of Things. Complementing and extending the Databox project is the EPSRC funded Defence Against Dark Artefacts (DADA), which seeks to respond to the security challenges that accompany the IoT.

"Hacking and disrupting services such as a telecoms provider causes distress and damage, but the prospect of a hacked vehicle or home security system could bring a whole new level of consequences – like losing control of your car or opening up your home to criminals."[1]

DADA extends our focus on the IoT from privacy to security and reliability. Of particular concern to us is that IoT devices do not simply collect and exchange data, they also act upon it. IoT devices 'actuate' and thus have physical consequences, such as unlocking your car or your home, rendering them subject to violation. The solution often advocated for security is encryption of data to a cloud service, but as highlighted by a recent Which? report on Smart Home Surveillance[3], that results in a great many IoT devices distributing personal data invisibly, and building in a reliance on 'always-on' connectivity – it is clear that there is more to secure and reliable IoT than simply encryption.

DADA focuses its security research on the home network. This is a largely ignored area where network infrastructure is minimal, with often little or no isolation between connected devices and the data they carry, but one that is critical to the uptake and use of IoT devices and smart consumer services that ride on them. We seek to model and profile the behaviours of IoT devices, to understand normal and abnormal behaviours, to identify security problems - both in terms of insecure and invisible communications - and to enable effective end-user insight and management of the domestic IoT.

One of the key challenges that accompanies exposing invisible device behaviours and communications to users is the social accountability that attaches to them. Simply put, that 'X' device was being used at 'Y' time enables 'Z' to be identified and held accountable for their actions - for example, a teenager playing online games at 2 o'clock in the morning. Addressing security concerns in the domestic IoT will then raise privacy and ethical challenges that also need to be researched.

"Outputs of the project will consist of a public Wikipedia-style repository of IoT device profiles maintained by developers, which can be drawn on by the public at install time to understand what they are actually putting on their networks. The repository will be updated with data about IoT device behaviours and communications provided by the Databox platform. The project will explore with potential end-users the kinds of interfaces and interaction mechanisms needed to enable the socially responsible and responsive management of IoT devices on the home network." Derek McAuley

1 Connection and Protection in the Digital Age. The Internet of Things and Challenges for consumer protection, Consumers International, April 2016
2 The EU General Data Protection Regulation, and UK Data Protection Act 2018
3 Which? investigation reveals 'staggering' level of smart home surveillance

https://www.databoxproject.uk/about/
https://www.horizon.ac.uk/project/defence-against-dark-artefacts/

“We are delighted to have been awarded an EPSRC Impact Exploration Grant to further the impact of the ‘Fairness Toolkit’, and continue a dialogue around issues of bias, trust and fairness. We have also received funding from the EPSRC for ReEnTrust – a new interdisciplinary project between the Universities of Nottingham, Oxford and Edinburgh – to extend the work of UnBias, exploring new technological opportunities for platforms to build and enhance user trust in algorithms.”

The UnBias Team

The vast expansion of the internet and the services offered comes with a price. Our lives are now ‘datafied’ on an unimaginable scale, as online services collect a wealth of information about our lives, who we live with, our health information, our financial affairs, where we are - the list is endless. Children are not immune from these practices when online. From the parents’ first Facebook post announcing their child’s birth to children themselves uploading photos and content onto their social media accounts, their lives are leaving an ever-growing digital footprint in the online world.

UnBias is a collaborative research programme between the Universities of Nottingham, Edinburgh and Oxford, addressing concerns, perspectives and experiences of internet users with regard to algorithm mediated internet services.

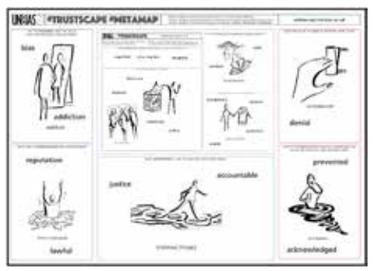
The range of services offered and facilitated by the internet continues to grow vigorously, assisted by the increasingly prevalent ‘smart phone’. This has affected us all, not least children and young people, who now find themselves born into a digital era. Yet do they know how online platforms and other websites work? Are they aware of what data might be being collected about them? What happens to this data? How might bias play a part in algorithm driven services? These are some of the questions that the UnBias Team sought to answer.

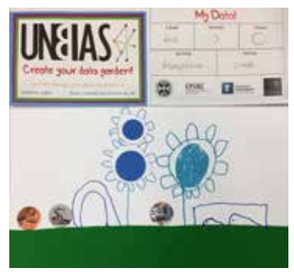
Concerned with children’s online experiences, we worked with 13-17 year olds to discover what they knew about algorithmic driven services, to learn about their experiences and gather their recommendations for change. Despite being large users of the internet, we felt they were a neglected group who were being left out of these important discussions, and we wanted to present their recommendations and allow them a say in their future internet.

Core to our work, children were involved in all stages of the research and we introduced the ‘jury method’ to encourage and guide youth-led discussion. We ran a pilot Youth Jury to try out some newly created activities to help children and young people learn about how the internet might affect them, and to prompt discussion on this topic. This led to us recruiting young people to join our Youth Advisory Group which proved to be a key part of the project - after all, who better to consult than the young people themselves? They were able to give us feedback on their experiences of participating in the pilot Youth Jury, put forward ideas to ensure that our future jury activities and discussions were accessible to all children aged 13-17, and provide invaluable input to guide us through the challenging terrain of engaging children and young people with these tricky concepts. In addition the Youth Advisory Group helped us prepare a report to share with the children, young people and other stakeholders, including schools and colleges: ‘Youth Juries- what we learned from you’. To ensure that the voices of children and young people were heard, we shared results of our Youth Juries with policy makers, academics and industry, through contributing to Government inquiries and writing academic papers.

Throughout the project it was important to be inclusive. We reached out to all members of the community by attending events that attracted a wide variety of age groups including families, such as the Nottingham Festival of Science and Curiosity and STEM Festival. We designed a range of activities to raise awareness of algorithmic bias and online fairness, and to encourage discussion - one activity involved primary school children creating their own ‘data garden’ to consider the effects that online searches may have. We also ran ‘polls’ where the general public voted on the outcomes of real-life examples of algorithmic bias.

A key outcome from UnBias was the development of a **‘Fairness Toolkit’** co-designed with young people and stakeholders, to stimulate discussions on issues of bias, trust and fairness in online systems. The toolkit consists of three components. The first is a set of **‘Awareness Cards’** to consider the role algorithms play in our lives and the effects that they may have. The second part is the **‘TrustScape’**, a thinking tool encouraging users to reflect upon their personal issues of trust and fairness when online. These ‘TrustScapes’ are then shared with stakeholders in the ICT industry, policymaking, regulation, public sector and research, who then feedback their views on these concerns using the **‘MetaMap’**, the third part of the toolkit.





Ella and Pratik share their UnBias Youth Advisory Group experiences

Taking part in the UnBias Youth Advisory Group and the Youth Jury allowed us to gain a plethora of knowledge and new experiences. As well as being part of real-life research, we also gained something else to put on our UCAS applications and CVs. We decided to volunteer to become members of the advisory group as we wanted to learn about subjects which aren't discussed or debated in college, and we wanted our voices to be heard. We also wanted to be part of research which would make a real impact for the future and also to learn about real-life issues which can affect us all.

We focused on improving a range of resources related to this subject. For example, we made a recruitment flyer more appealing to 13-17 year olds to encourage their participation, and improved some of the resources used in discussions by suggesting ways in which they could be more representative of the data we expose on the internet (through filling in questionnaires, shopping online and using social media). We came up with the idea of using currency which correlates with the value of data shared online, and took part in creating our own filter bubbles to compare what we saw on the internet to what others saw, and why certain information may be hidden.
Being part of this group has helped us understand that companies have a large amount of power over our data, how we can protect what we share online, how companies are able to make money from our data, and how we can be safer by using alternative search engines such as DuckDuckGo or incognito. We now have a much better understanding about algorithms and how they can lead to deviant behaviour, but are more aware that some companies are trying to regain our trust.

"We really enjoyed working with Ella and Pratik and appreciate their feedback. A big thank you to you both"

The UnBias Team

UNBIAS

Timeline

- Research Activity
- Policy Impact
- Outreach

2016

- Evidence submitted to 'Children and the internet' Parliamentary inquiry
- Design of UnBias Youth Juries
- Recruitment of participants

2017

- First round of Youth Juries
- House of Lords Report 'Growing up with the internet' – output of Parliamentary 'Children and the Internet' inquiry
- Evidence submitted to 'Fake news and algorithms in decision making' Parliamentary inquiry
- Curiosity Carnival European Research Night
- MozFest drop-in workshop
- Pilot Youth Juries
- Youth Juries Advisory Group formed at ESRC Festival of Science

2018

- Second round of Youth Juries
- Nottingham Festival of Science & Curiosity
- Evidence submitted to 'Mental Health and Social Media' Parliamentary inquiry
- Science Technology Engineering & Maths Festival (STEM) 'How to create your own data garden' workshops
- Won EPSRC Telling Tales of Engagement and an Impact Exploration grant
- Evidence submitted to the Information Commissioners Office' (ICO) call for 'Age Appropriate Design Code'
- Fairness Toolkit launch
- Launch of Youth Juries Report 'What we learned from you'
- 'Algorithmic awareness building for user trust in online platforms' workshop with the Internet Society

Ansgar Koene talks about promoting Horizon research to policy makers

One of Horizon's key aims is to support informed policy setting in the digital economy and we design policy engagement into our research from the start. We achieve this through gathering the views of a broad set of stakeholders – including industry, third sector, and the public – on the use of personal data in the provision of digital services, privacy and ethics, algorithmic bias and trust. We actively monitor the UK and European Parliament to contribute evidence, develop recommendations and provide tools for educators, designers and decision makers. This stakeholder engagement, and the resulting evidence we have accumulated, has gained Horizon a reputation as a trusted source of information and set the foundation for strong relationships with policy makers, regulators and standards-setting institutions. Two examples of how our research has influenced policy come from our UnBias project, and out of our work with 5Rights.

The EPSRC-funded UnBias project explores the experiences of users as they interact with algorithmically-mediated online services. This aligns with work by the IEEE Global Initiative on Ethics for Autonomous and Intelligent Systems to develop ethics-based industry standards, and presented us with an opportunity for impact on the design and development of algorithmic systems. As a result, I volunteered to chair a working group to develop the IEEE P7003 Standard for Algorithmic Bias Considerations. Following an invitation from the European Parliament Research Services to produce a Science Technology Options Assessment report on 'A Governance Framework for Algorithmic Accountability and Transparency', we presented this in person to the European Parliament in Strasbourg.

Our long association with children's rights charity 5Rights led to us making an important contribution to the Information Commissioners Office (ICO) consultation on the Age Appropriate Design Code – taking into account the needs of children when designing online services. Ramifications of this work are shaping future research agendas, for example two 'Network Plus' projects funded by the Research Councils with Elvira Perez on the team: the Human-Data Interaction Network that aims to bring ethics to the forefront of systems design, and the Nurture Network that promotes children and young people's mental health in a digital world. Our work with 5Rights is ongoing and involves an exciting ground-breaking initiative to support the United Nations Committee on the rights of the child, which will set a new international standard for children's rights in a digital world.

Our engagement with the UK Government has included the submission of research evidence to a number of Parliamentary inquiries. In addition Derek McAuley has presented oral evidence to Committees from both the House of Commons and the House of Lords, was appointed as 'special advisor' to the Digital Platforms inquiry, and served on the expert panel convened by the Chancellor to review the UK's competition regime in the context of the digital economy.

www.hdi-network.org
www.enurture.org.uk

"If we are going to make progress in fixing a digital world to ethical standards we need computer scientists and academics to work alongside civil society and policy makers. No one group can make this important change alone. The work of the UnBias project has been central to our understanding of how policy should be framed, and by working together I believe we are about to make a step-change in how children experience the digital environment."

Baroness Kidron OBE

Some examples of our contributions to UK Parliamentary inquiries:

- House of Lords Communications Committee inquiry on 'The Internet: to regulate or not to regulate?'
- House of Lords Communications Committee inquiry 'Children and the internet'
- Commons Science and Technology Committee inquiry on 'Impact of social media and screen-use on young people's health'
- Lords Select Committee inquiry on Artificial Intelligence
- Commons Science and Technology Committee on 'Algorithms in decision-making'
- Commons Digital, Culture, Media and Sport Committee inquiry on 'Fake News'

Good design is an important element in the digital economy, but there is relatively little research or long-term data-driven analysis of the design process. Ideation cards have been developed and used for many purposes, and yet we know little about how they contribute towards and shape the design process. Horizon has been introducing ideation cards to different audiences to engage and facilitate discussions relating to complicated digital concepts.

One of the earliest examples of ideation card use in design dates back to the 1950s with 'The House of Cards', a card set designed to aid innovative thinking in design. Since then, cards have increased in popularity, particularly within the fields of user experience and human-centred design, and some argue that card-based tools have various advantages over other types of media in aiding the process. Studies have shown that using cards allows for further developed, more creative and diverse outputs, and users and facilitators report more effective communication and an increase in the ability to focus on a given topic. Furthermore, they have been found helpful in mapping out projects and approaches in a team context in addition to explaining plans and ideas to other stakeholders.

Given these benefits, we have designed and featured **ideation cards** in a wide variety of research projects to drive engagement with diverse audiences, including young people and children, lawyers, educators, the creative and cultural sector, students and gamers. Taking this a stage further we have developed a novel **platform** to capture, analyse and visualise data about how the cards are used during and across design sessions, preserving the knowledge and allowing further insights to be gained.

The cards:

The UnBias project worked with young people and children to create **Awareness cards** – an element of a larger toolkit to promote awareness of, and stimulate public dialogue about, algorithms and how they shape online experiences. The cards encourage discussion and debate to explore issues such as data privacy and protection, and they support the development of key life skills including critical thinking and effective communication.

Our **Moral-IT and Legal-IT cards** help explain legal and ethical principles to non-experts. The Moral-IT deck focuses on the ethical side of design and technology, including privacy, ethics, law and security. The Legal-IT deck orientates more towards legal frameworks such as the EU General Data Protection Regulation – what they mean, how to incorporate these into the design process, and in particular the new requirements for legal compliance by design and default. We introduced the Moral-IT and Legal-IT ideation cards to each of the projects in our Services and Products Campaigns. Applying this methodology encouraged open dialogue between researchers and stakeholders to review and consider project activity and to address the motivation, purpose, risk and potential consequences that could arise as a result of our research.

"The cards came in very useful… they are not only useful devices to inspire creative projects, but also set about challenging those ideas with 'disruption cards', posing pragmatic questions about how the project will work in practice – a creative, fun way of carrying out your risk assessment. By responding to the challenges posed on the VisitorBox 'disruption' cards, we were able to focus our ideas and simplify our initial thoughts."

Ditching Museum of Arts & Craft – Medium blog

Cards developed as a component of the **VisitorBox toolkit** supported the creative and cultural sector with training initiatives in digital technologies and aiding deployment of engaging visitor experiences.

A set of **Politics in Games cards** have been used to address political content and engagement in video games. They support designing games with political content, to help game designers understand and better comprehend any politics that feature in their games. In addition, they enable activists and people working in political engagement to create games that allow them to convey their causes, without previous knowledge of game design.

The platform:

We wanted to explore how usage data from ideation cards sessions can enable further reflection on design, and we developed the **Cardographer Platform** as a result. Using image recognition technology aided by augmented reality, we were able to capture and analyse data about card use during and across sessions, and add these to a global repository of designs and evaluations enabling users to identify trends, untapped opportunities and issues. As the repositories grow in size, so does the complexity of the data, and the potential of the accumulated knowledge recorded. By enabling the data to drive dynamic and interactive visualisations, users can see results over time and across projects, quickly home in on points of interest, see patterns in the use of cards, and understand similarities in approaches and thinking between seemingly different designs.

The innovative nature of works delivered by the Horizon Media Campaign, alongside their public visibility, has served to trail blaze new formats of data creativity for mainstream creative industries. The activities attracted wide media coverage to enhance public awareness of, and appetite for, new emerging forms of cultural experience.

The Horizon Media Campaign worked with over 50 Partners to provide training and support to practitioners and artists. We created a portfolio of more than 40 new installations, touring and performing at over 40 venues across 26 cities worldwide, and reaching an audience approaching 65,000.

Adopting the 'research in the wild' approach, we worked with artists to create, deliver and study new cultural interactive experiences embedded with digital technologies to enable capture of participant engagement data during public performances and touring. In addition to sharing our findings with academic audiences, the data collected during touring of works allowed us to deliver benefits to artists, to support expectations of their work and provide recommendations to inform future design and deployment opportunities.

We worked with Thrill Engineer Brendan Walker on **VR Playground** – a project investigating the relationship between 'real motion' and 'apparent motion', immersing people into a virtual reality adventure on a playground swing – built on the idea of the rider as a performer. VR Playground toured extensively across the globe, featuring at the PyeonChang Winter Olympics 2018 cultural programme and at the Kimmel Centre in Philadelphia USA, reaching audiences of over 27,000. Data captured from the headset and swing seat were used to represent swing patterns to provide a better understanding of the relationship between movement and visual experience. This in turn informed the creation of different types of visual motion adventures to enhance rider experience further.

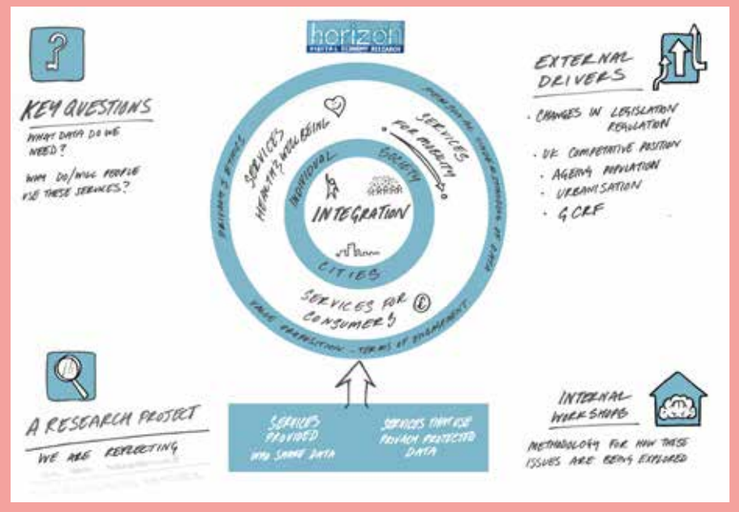
Our work with Artist Mat Collishaw on **Thresholds** – a mixed reality portal transporting people back to the first photography exhibition by Henry Fox Talbot in 1839 – focused on sensation. We invited people to move around a physically constructed space, while touching, feeling and interacting with geometrically synchronised objects viewed through a headset. Thresholds toured to a number of prestigious art galleries globally including Somerset House in the UK and Yapi Kredi Cultural Centre in Istanbul, Turkey. Data captured from headsets provided information showing how people moved around the experience and engaged with physical and virtual content, allowing the artist to fine-tune it as it toured.

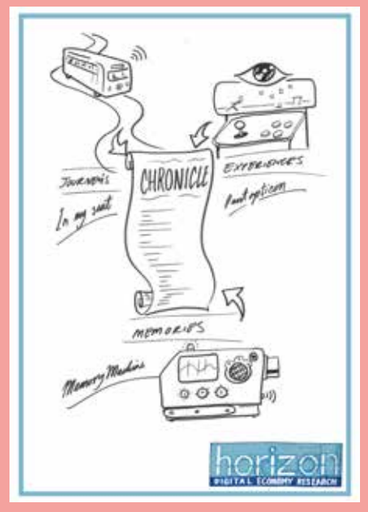
We worked with Richard Ramchurn, filmmaker and Horizon CDT student, to create a brain controlled movie called **The MOMENT**. By tracking levels of attention and measuring electrical brain activity, the technology enables viewers to choose individual journeys from a number of different storylines throughout the film. The MOMENT toured to a number of venues globally in unique style with showings in a caravan. Most notable was the British Council SPARK Festival, an event recognised for cultural exchange between the UK and Hong Kong and celebrating creativity across arts, sciences and education. An analysis of the data collected from participants provided an overview of routes taken through different pathways in the film. Interviews with people who watched the film gave rich feedback about how attention can be used to control personalised interactive movies and games.

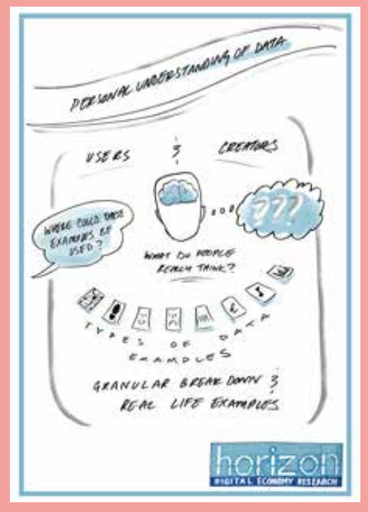
Climb! is an interactive classical piano performance with a twist. Working with Maria Kallionpaa, Classical Music Composer, and colleagues from the University of Oxford, we developed Climb!, a playful piano performance drawing on interactive techniques used in the soundtracks of modern computer games to test the skills of the performer with a series of 'challenges'. Climb! was performed to audiences attending events including 'All in Your Bass Computer Music' festival at the Royal Concert Hall, Nottingham and the Littala Music Festival in Finland. Analysis of data from the performances helped us understand how humans can creatively engage with complex autonomous systems, adopting strategies of taming gaming, riding and even becoming the system.

The Running Hare was a project with Roma Patel, a Scenographer, Digital Artist and Horizon CDT student. This interactive installation provided the opportunity to extend our research into the area of 'digital creative play' and involved meeting the requirements and expectations of a younger audience. Data generated through observation and interviews with children engaging with the play area and their parents contributed towards the design of a second installation, **The Enchanted Forest**. This was commissioned by the Hullabaloo Children's Theatre in Darlington and was extended due to public demand.

www.horizon.ac.uk/about-horizon/impact-horizon-media-campaign







Advanced digital technologies are being increasingly embedded within services that we adopt and often become reliant upon. This shift towards the use of digital services comes with risk as we share our personal data to access online platforms that help us monitor and manage our finances, travel, health and wellbeing, and many other aspects of our everyday lives.

The overarching aim of the **Horizon Services Campaign** is to gain a better understanding about the challenges faced by sharing our personal data with digital service providers. In conjunction with our industry partners, we developed different proof of concept digital services to act as probes for research into their impact on consumers and the implications for privacy and trust.

We instituted a range of methodologies within these projects. Stakeholder workshops enabled co-creation of the digital services. The use of Moral-IT and Legal-IT ideation cards – tools developed by Horizon in earlier research – to facilitate reflection and discussion on ethical and legal issues within each of the projects, helped us identify and embed safeguards into the new technologies. In addition, we worked with internet users to gather and examine citizens' thoughts and understanding about how their personal data is used.

Whilst the domains of application of digital services may differ significantly, the underpinning technical approach to delivering them has a number of similarities and consistent requirements. We therefore developed a software platform, **Chronicle**, to underpin and support each of these projects. Chronicle stores a digital representation of a timeline of a 'thing', the thing and the events on the timeline being defined by each project, for example memories in the Memory Machine project. The platform is customisable and was tailored to meet the requirements of each project, but we also wanted answers to important questions such as: What does it mean to delete something from an historical record? Should deletion be possible, or should a record remain indelible? If so, what would be the implications for privacy and ownership rights?

We explored a range of services, each chosen to reflect the sharing of different types of personal data with diverse stakeholder groups:

Memory Machine (MeMa) focuses on our sense of identity, aiming to capture people's identities through memories. The blending of personal and factual data provides an opportunity to shape how people wish to be remembered, while creating an afterlife legacy. As a potential health and wellbeing application, we are collaborating with the Institute of Mental Health and the Centre for Dementia. Working with older adults, people with early symptoms of dementia, care home managers, historians and media experts, we seek to elicit personal stories and explore topics including privacy, consent, data security and ethics. We are also addressing challenging issues such as painful memories, or events we may want to forget.

In My Seat is engaging with the public around use of their personal data to improve their journey experience on public transport. By working with bus users and stakeholders, we are exploring the exchange of data between bus operators and travellers through the development of an app providing dynamic, location-based, real time information. As well as practical information for bus users such as end-to-end route planning and live updates on the service, the app also provides location and profile-based notifications tailored to the current journey, offering passengers the opportunity to learn about their local surroundings as well as their destination. The app will choose what content is shared with the bus user and the operator does not need to be part of this information exchange. The intention was to include user-generated content from other travellers, but understandably the operators did not want information they had no control over associated with their service. This highlights some of the challenges encountered when developing digital services and managing data use and distribution.

Panopticon is producing a framework for tracking the interactions of people with products in public indoor environments, to create personalised 'visitor experiences' that are more meaningful to audiences, and at the same time providing venues with valuable information to continually improve the experience and drive repeat visiting. We worked with the National Videogame Arcade (NVA) to capture video footage of visitors engaging with interactive exhibits, and analysed the data with computer vision techniques to build measures of their emotional responses. This tracking of visitors' movements and behaviours is valuable to the curators of public spaces, but it yields large amounts of unnecessary data and is very invasive. In order to address this, we combined the data with a physical token which was offered to visitors to use when engaging with interactive exhibits at the now rebranded National Videogame Museum (NVM). The tokens captured their movement and emotional responses and have the potential to be developed into digital souvenirs, but the important aspect of this is that visitors could voluntarily gift these back to the venue, thus allowing them to provide their consent to the venue to use their data. The NVM was then able to analyse an individual's experience, to provide a better understanding of the performance and appeal of their interactive exhibits.

Hybrid Gifting is exploring how physical products may be combined with digital media to produce novel hybrid gifts, aiming to enhance the experience of 'giving' and 'receiving' gifts, and to support emerging gifting practices. As a result of working with Debbie Bryan, an independent creative retailer in Nottingham, we created a gifting app that enables 'givers' to curate and share media as part of a physical gift. 'Receivers' of gifts open the digital content embedded within their gift via the app and can further personalise it by adding additional media, with access to the digital content being managed through the Horizon Chronicle platform. We are examining what it means for people to associate personal content with a physical artefact as part of a sharing experience – in the manner of a closed privacy-preserving online interaction – and the value of hybrid gifts and their impact on the giver/receiver relationship.

Activities introduced to better understand the use of personal data in these projects demonstrated the importance of privacy, particularly with regard to the context in which the data is shared. Whilst in one context sharing a particular type of data might seem reasonable, in another it may be seen as invasive and alarming. The studies showed that users have complex ways of understanding their personal data. Our users came up with more than 20 distinct ways of describing their data, and there was a complex relationship between these descriptions – some is seen as personal but not necessarily sensitive or private, and when it has implications for other people (family members, friends) this affects how willing people are to share it. Operators and providers of services expressed concerns relating to the responsibilities involved in collecting and retaining users' personal data, and ensuring compliance with the General Data Protection Regulation (GDPR). Our activities highlighted the complexity of systems using personal data, such as the developer's responsibility for system (mis) use and how a correct understanding of a system's operation can be ensured. The need for human oversight, clear and transparent communication relating to privacy agreements, and how captured personal data would be stored, processed and used was highlighted as particularly important.

In order to share the concept of the Horizon Services Campaign to a wide and varied audience, we commissioned Rikki Marr – a creative and live illustration agent - to produce a series of illustrations, some of which are included in the link below.

www.horizon.ac.uk/research/research-activities/services

The ability to innovate new products and means of production lies at the heart of the UK's competitiveness, productivity and future prosperity. Digital technologies can fundamentally disrupt the nature of products and how they are designed, produced and used – in other words, our smarter products are now being made in smarter ways.

The **Horizon Products Campaign** is the third in the series, developed in collaboration with the University of Nottingham's Smart Products Beacon, and fusing Horizon's personal data agenda with the design, manufacture and use of products. We have developed three projects to communicate clear everyday stories and to provoke deeper thinking and discussion about the future of smart products.

In food and drink manufacturing, a third of working time is spent cleaning, which significantly affects productivity and efficiency. **RoboClean** aims to understand and address the industry need for cleaning support technologies by developing and deploying human robot collaboration to assist in the cleaning of factories, and detect the unwanted presence of allergens to prevent food safety events. It will explore how robots equipped with integrated allergen sensors can work with humans as part of a team to better clean a factory floor, combining the different perceptual abilities of each to the best effect. This is a manufacturing challenge that many factories will recognise, and has the potential to be relatively easily adapted for different sectors.

Traditionally 'food design' has been an area of expertise for Chefs, where raw materials are combined and cooked or processed, resulting in the blending of multiple components to create a dish. However, the food engineering involved in current culinary processes needs extensive testing of exotic ingredients, which requires control and high levels of precision. Food is also a highly regulated commodity where, in order to bring a food to market, various mandatory requirements must be met. **Food Design for Future Dining (FD)²** will address a number of questions through creative technologies and engineering research – designing and demonstrating prototypical digital foods that provide novel physical and digital eating experiences.

Collaborative robots, or co-bots, are robots that work collaboratively with humans in a productivity-enhancing process, mostly associated with manufacturing and/or healthcare domains. Despite the aim to collaborate, co-bots lack the ability to sense humans and their behaviour appropriately. Instead robots rely on physically mechanical, hierarchical instructions given explicitly by the human, instead of utilising a more natural means to include pose, expression, and language, and utilise this to determine behaviour. In turn, humans do not understand how the robot makes its decisions. Industrial **Co-bots Understanding Behaviour (I-CUBE)** will enable research in human-robot cooperation and bring together the know-how and research interests of human factors work, automatic human behaviour analysis and machine learning. Based on a laundry sorting co-bot task, we will investigate how humans and robots explain their tasks, cope with mistakes and guide each other to overcome (impending) failure.

Our vision is to enable the innovation of ever more personalized products alongside the ability to make them in even more agile ways. Yet these same technologies raise widespread concerns to society about the trusted use of personal data, and whether the benefits will be inclusive and accessible for everyone. We will apply the Horizon Moral-IT and Legal-IT ideation card processes across the three projects to help us build an understanding of people's attitudes to the use of their personal data in these scenarios (for example, when working together with robots), and to gather any key learnings that may have wider applicability.

www.nottingham.ac.uk/research/beacons-of-excellence/smart-products/smart-products.aspx

iCUBE

Transitional Assistant Professors

In common with the original Horizon project, the follow-on funding has been used to train a new generation of early career academics in interdisciplinary research. The mechanism reflects aspects of the original EPSRC Transitional Fellow programme, in which the researcher transitions from a research fellow into a full-time academic post over four to five years, allowing them to focus on training, funding development and research initially, while gradually picking up teaching and administrative duties. We have appointed four Transitional Assistant Professors in Maths, Computer Science and Engineering and focus on two of these.

Mercedes Torres Torres

My interest is in machine learning and image analysis and processing, in particular relating to the medical environment.

The **Unobtrusive Behaviour Monitoring project** investigates our everyday interactions with different utilities and devices – such as kettles, mobile phones, bank cards. It combines all the information generated through connecting with these technologies, to present it in a constructive and organised way while identifying different patterns in behaviour. This type of analysis could be particularly insightful in relation to health and wellbeing. For instance, people suffering from mood disorders could use it to monitor their condition and set early warning signs to support a greater self-awareness of personal triggers.

I have also been working with colleagues at N/Lab, expanding on previous research developing land-use classification – an environmental exercise that involves mapping an area according to characteristics of the land, to produce rich information on the types of human activity being carried out there. Information from these types of maps can be used to study the environmental impact that different planning decisions may have on a community. For example, agencies will use the maps to decide where facilities such as hospitals should be located, or where roads could be built.

In addition to organising Ada Lovelace activities at the University of Nottingham, I am delighted to be part of a team supporting **TechUp** (@TechUp12), a new digital training programme funded by the Institute of Coding to encourage women to train in the digital sector, an industry that is still largely male dominated.

James Pinchin

My interest is in the design of tracking technologies driven by human needs and concerns, and I'm involved in a series of projects which investigate the generation and use of movement data, to address questions about behaviour and the design of places and systems.

"If you're better informed, you can do your job better."
Amanda Simpson, Senior Nurse Clinician,
Aintree University Hospital NHS Foundation Trust.

The **WayWard** project, funded by the Health Foundation, in partnership with the Royal College of Physicians (RCP), identified how data could be used to deliver impact. This included the allocation of hospital staff in out of hours care, managing allocation of tasks, redesign of ward layout, supporting junior doctors' training and enabling innovation and development within hospitals. Our research findings featured in the RCP workforce policy: 'Safe Medical Staffing Working Party Report'.

"The data produced by WayWard ticks every single box – it focuses on patient care, it supports professionalism and can address staff morale, and it can be used for improved training of future staff."
Professor Frank Joseph, Future Hospital Officer
at the Royal College of Physicians, London.

I'm now leading **WISEParks**, one of five projects forming 'Rethinking Parks' - a joint programme between The Big Lottery, The Heritage Lottery and NESTA aiming to create more cost effective and privacy aware solutions for Park Managers who face the challenge of understanding park users and usage.

www.wayward.wp.horizon.ac.uk
www.horizon.ac.uk/project/wiseparks

Horizon success is gained through the achievements of our team – through special awards and promotions, or recruitment to follow-on roles in academia and industry. We are proud to report a number of recent achievements:

After six years at Horizon, **Lachlan Urquhart** secured the post of Lecturer in Technology Law at the University of Edinburgh.

"My time in Nottingham has been amazing and I've worked with many brilliant people there. Working at Horizon has broadened my perspectives on what research can be, particularly by introducing me to a multidisciplinary way of thinking."
Lachlan Urquhart

Murray Goulden joined Horizon in 2009 to study emerging digital technologies from a sociological perspective. He is now a Nottingham Research Fellow based in the School of Sociology, and is exploring the implications of Internet of Things technologies in the home.

Ben Bedwell and **Laura Carletti** have moved on to new roles. Ben is Digital Research Specialist within the Digital Research Team at the University of Nottingham, and Laura is European Policy Manager in the Research Operations Office at the University of Cambridge.

Elvira Perez Vallejos took up the role of Associate Professor of Digital Technology at the National Institute of Health Research Biomedical Research Centre, Institute of Mental Health. She continues to collaborate with us to investigate the risks and opportunities that the digital world offers – and sometimes imposes on – our mental well-being.

We also said goodbye to **Javid Holland-Yousaf**, after 3 years as a Developer with us – he is now a Spatial Application Developer at the British Geological Survey.

Christian Wagner, former Horizon Transitional Fellow, has been promoted to Professor of Computer Science at the University of Nottingham – a notable achievement in such a short space of time.

Tom Rodden was elected as a Fellow of the Royal Academy of Engineering – one of the highest honours for an engineer in the UK – in recognition of his outstanding and continuing contributions to the profession.

"I am delighted to be elected as a fellow of the Royal Academy of Engineering. It is a great honour to be elected by my peers to join the academy and I am grateful to many colleagues at Nottingham and elsewhere I have worked with over my career."
Tom Rodden

John Harvey and **Bertrand Perrat** joined Horizon CDT students Maddy Ellis, Vanja Ljevar and Dominic Reedman-Flint at N/Lab – the centre of excellence for international business analytics at the University of Nottingham. N/LAB was founded by members of Horizon's former Neo-demographics research group. Mark Iliffe, former CDT student and Geospatial Lead at N/Lab, moved to New York to take up the role of Geospatial Innovator at the United Nations Global Geospatial Information Management.

Sarah Sharples was appointed to the Council of the Engineering and Physical Sciences Research Council (EPSRC), where she plays a key role in helping shape the future of research and innovation in the UK.

"EPSRC invests more than £800 million a year in research and training in engineering and the physical sciences and I'm honoured to take up this role."
Sarah Sharples

And finally, we are delighted to announce that the Horizon Centre for Doctoral Training (CDT) has been awarded a third round of funding from the EPSRC. The CDT – Creating Our Lives in Data – will train a community of 65 future leaders to harness digital technologies to make smarter products in smarter and responsible ways. The centre brings together leading figures from computing and engineering as well as the social sciences, business and humanities, including researchers from the Centre for Computing and Social Responsibility at De Montfort University, and is co-funded by over 40 industry, third sector and international partners.

"The Horizon CDT provides a uniquely innovative programme where highly talented PhD students from multiple disciplines work together to explore future products for our Digital Economy."
Steve Benford

What's next?

Horizon has been privileged in receiving two rounds of funding from the EPSRC. Our current programme – From Human Data to Personal Experience – will end in July 2020 and whilst we have many ongoing projects creating important impact, we aim to leave a full and varied portfolio of pioneering Digital Economy research. We have successfully established over 130 collaborations and partnerships across diverse sectors – including digital, communication and information technologies, the creative and cultural industries, energy and the environment, health and wellbeing, manufacturing, retail and transport. Delivering in excess of 1000 engagement activities and disseminating our findings among audiences totalling over 300,000 globally, our research findings have contributed towards influencing policy and practice in a number of ways.

The political and societal landscapes for technology are changing and increasingly the big technology players are being challenged in the role they play and their impact on society. The careless attitude towards personal data, and the use of closed technologies that stifle innovation and foster 'a winner takes all' environment, has been a focus for Horizon. Derek McAuley was a member of the UK HM Treasury Furman Review of Competition in the Digital Economy which indicated the need for strong enforcement of acceptable behaviours, combined with data mobility and interoperability to promote competition, and there is still much to do to realise the potential for privacy-respecting personal data products and services.

However, challenged as we are already, continued technological developments promise a future of cyberphysical systems – a convergence of ubiquitous computing and communication technologies with emerging uses that actuate in the real world. We are bombarded with visions of how smart grids will regulate energy flows, activating devices; smart transport systems will control driverless cars; robot carers will look after us; while prosthetics and implants will actuate our bodies for us. No longer will these systems only sense and respond digitally, but they will interact physically, ultimately becoming embodied and autonomous.

Looking beyond the base capabilities of the technology, the research required to understand the human and social issues of living in a cyberphysical world is barely nascent. Hence, we are only now scratching the surface of the consequential implications for how the technology will need to be transformed from predominately techno-deterministic views to human-centred views.

Work has already started. Our Products Campaign has set out to target business sectors that traditionally revolve around different kinds of physical products, and explore how these will be transformed through emerging Internet of Things technologies coupled to human data. We have been able to take this forward jointly with the recently funded University of Nottingham Smart Products Beacon which will continue the work started in Horizon.

Our thanks to Emily Mantell for her guidance on the cover layout.

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