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Broadening horizons in the Digital Economy

Horizon Centre for Doctoral Training

horizon CENTRE FOR DOCTORAL TRAINING

Digital Economy Transforming Business and Society

Autumn 2019
cdt.horizon.ac.uk

Contents

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Design: Creative Triangle

Introduction

The Horizon Centre for Doctoral Training was initially established in Autumn 2009 as a doctoral training centre, funded by the Engineering and Physical Sciences Research Council (EPSRC) to train cohorts of research students within the digital economy ubiquitous computing arena.

In 2014, the CDT was successful in receiving renewal funding from the EPSRC with 'My Life in Data' becoming the core research theme for the University of Nottingham based Centre.

As of Autumn 2019, we have recruited **over 120 CDT students**; grown a **network of 100 supervisors** across various disciplines and universities; and collaborated with more than **40 industry partners** who have contributed over £1.2M cash funding so far.

55 students have submitted their thesis to date, (with **50 students** successfully passing vivas). The CDT has published over 300 academic research papers; and received multiple awards, including two best paper awards at the ACM CHI Conference and an Internet Society 'Global 25 under 25' award for Kate Green (2016 cohort), which recognises 25 young people around the world who are shaping the internet as a force for social good.

Employers of CDT alumni include Sony, United Nations, World Bank, Microsoft Research, BBC R&D, Airbus and Jaguar Land Rover, as well as many remaining in academia in world-class Universities, or choosing to start-up their own businesses or consultancies.

The multidisciplinary environment, the breadth of training, the extent of opportunities available to students, and the wide range of impacts including media coverage, prizes, awards and case studies are noted as key successes.

In September 2018, PhD candidate Alexandra Young was the first student of the renewed CDT to submit her PhD thesis entitled 'A Qualitative Study of Internet Use Comparing the Experiences of People with Physical Disabilities and Early Onset Dementia'.

In February 2019, the EPSRC funding was renewed with Creating Our Lives in Data being the research theme for the Horizon CDT.

This brochure has been produced to:

- highlight the breadth of innovative multidisciplinary digital economy research that is undertaken in the CDT, with the support of industry partners and world-class supervisors
- showcase the career paths of Horizon CDT alumni and describe how an Horizon PhD has equipped them to progress to professional positions in the thriving digital economy, and contribute to real-world impact
- demonstrate the various opportunities that are available for students within the My Life in Data CDT, and the plethora of skills, expertise and knowledge they can expect to gain as an Horizon CDT student

We have included case studies from existing students and alumni that we hope you find interesting and inspiring.

Professor Steve Benford
CDT Director

Professor Sarah Sharples
CDT Director

CDT partners

The Horizon CDT is fortunate to have collaborated with and receive support from over 40 partners from industry, government, innovation centres, creative agencies and not-for-profit organisations. Examples of current partners include BBC, Digital Catapult, GlaxoSmithKline, Internet Society, Nottingham University Hospitals NHS Trust, Ordnance Survey and Unilever.

Collaborations with digital economy organisations help contribute to the ways that CDT students will establish the technologies, applications and principles to enable citizens to construct digital identities from personal data and effectively manage them to derive economic and social value.

The PhDs that emerge from our CDT are therefore distinct from conventional PhDs; we produce rounded individuals with the skills to work in transdisciplinary teams, including technologists who appreciate the societal context for emerging technologies, and social scientists who are able to shape new technologies.

Each recruited CDT student is carefully matched with an industry partner based on their skills, qualifications and experience, with the aim of establishing and delivering strong mutual benefit for both the organisation and the student. The CDT student carries out a three month PhD internship with their partner organisation.

Why collaborate?

Industry partners have continual involvement at all stages of the PhD programme including the recruitment of the student, co- creating the research projects and hosting student internships. In addition, collaborators are able to contribute and help shape the CDT including contributing to doctoral training and strategic input into the Centre via Advisory Board membership.

Specific benefits of partnering with the Horizon CDT:

- It is a cost-effective way for organisations to be involved in relevant leading edge research in digital identity where you may not have the resource or expertise to undertake this alone
- The research project is co-created with the partner so the research is of real commercial significance to their organisation
- Our students are graduates who possess excellent academic track records and are highly committed to solving real world research problems. They experience broad training in transdisciplinary research and professional skills ready for careers in industry as well as delivering a relevant and innovative PhD thesis
- By hosting the student for internships, partners are helping shape the employees of the future who can make a significant impact in the global digital economy
- Through the CDT, partners have access to a network of expert supervisors across a range of disciplines, and opportunities to work with other industry partners

> “Within the Horizon CDT there is a whole host of disciplines that we value, from Human Factors through to English Studies, and the opportunity to bring those together in a multidisciplinary environment is extremely valuable to us.”
>
> Jeremy Morley, Chief Geospatial Scientist, Ordnance Survey

> “We have been very impressed with the CDT students; in terms of their work ethic, background knowledge, ability to quickly assimilate new project ideas and develop them to make a real difference. They have integrated well with the team it has been a pleasure to host them.”
>
> Brian Newby, Scientist, Unilever

> “We want students who come from the perspective of balancing technology development with the trusted use of personal health data.”
>
> Lindsay Edwards, Head of Data & Analytics, GSK

> “I can say it’s a real pleasure work with PhD students from the CDT, and immerse them in BBC research and partnerships, via the projects that play to the focus of the PhD and the overlap between research directions.”
>
> Phil Stenton, Research Scientist, BBC

PhD studentships

The technologies of digital identity and personal data pose some of the most profound technical and social challenges facing our digital society today. Our digital identities will define the interfaces to future services we will use for entertainment, wellbeing, government, transport, energy, retail and finance. They will be constructed from our personal data, digital records that capture who we are, and the histories of our digital, physical and social interactions.

We are at an exciting moment in time where there are a vast range of opportunities for research in personal data. The Horizon CDT offers the opportunity to shape the future by recognising a growing public awareness of the value of personal data, presenting exciting opportunities to address concerns over how data is being created, analysed and used.

Our vision is to create digital identity technologies that operate in a fair and transparent manner to empower their users. This is a transdisciplinary challenge, one that needs to bring together expertise in digital technologies, perspectives on digital identity from the social sciences and humanities, and a deep understanding of real-world applications.

The Horizon My Life in Data CDT provides a community of PhD students with the interdisciplinary skills to drive the digital identity and personal data agenda for the twenty-first century. While we do not expect every student to be an expert in all of the areas mentioned above, our aim is to train people to work in multidisciplinary teams, and be ready to become future leaders in industry, the third sector and academia.

More information on our current research can be found at **cdt.horizon.ac.uk**

Horizon CDT programme

Horizon adopts a radical approach to training that combines taught elements with industry engagement and practice-led research in a highly flexible manner.

Under the guidance of a personal mentor, each student will undertake a journey from an initially narrow disciplinary focus to a point where they are fully equipped for a career within industry or academia.

This will involve developing transdisciplinary skills in the human-centred design of ubiquitous computing, as well as transferable skills in research, innovation and appreciation of societal impact.

Our Centre for Doctoral Training programme comprises **three core elements**:

The **taught programme** involves **180 credits of modules** covering interdisciplinary and transferable skills.

Each student undertakes a **three-month internship** with an external partner during their first 36 months of study, contributing 20 credits to the 180.

The **research programme** involves a **20-credit PhD research proposal** with supervisors and external partners from multiple disciplines and follows a proposal developed during the first year of training.

PhD research topics will be developed during the first year of the programme, drawing on ideas and discussions involving the students, potential supervisors and external partners.

The following list offers a few illustrative **research topics** that would fall under the overarching agenda of the CDT:

- An exploration of factors that influence desire to share genomic information
- Brain controlled film
- Using personal data to configure navigation support for blind and partially-sighted people
- Understanding rail travel through the curation of personal data
- Enchanted smart objects for health behaviour change
- Studying the potential effects of smart packaging on customer brand engagement within the fast-moving consumer goods industry
- Human-Machine Interface design for navigation systems in future highly automated vehicles
- Using data to support citizen-centric smart cities
- Embedding digital interventions into everyday life – Measuring mood with wearable technology

CDT internships

Horizon CDT students benefit from a three month internship with their sponsoring industry partner, or with an organisation that will be of benefit to the student's research and collaborating organisation.

Students have completed internships in countries such as Denmark, India, Japan, Malta, Tanzania, the United Kingdom and the United States of America.

Examples of organisations where Horizon CDT students have already completed internships include:

- BBC Research & Development
- Cambridge University Press
- City Arts Nottingham
- Digital Catapult Centre
- Experian
- International Institute of Information Technology – Bangalore (India)
- ISOS Group
- Locision Technology Limited (Hong Kong)
- Microsoft Research Lab – Cambridge
- National Videogame Arcade
- Network Rail
- Nottinghamshire County Council Public Health
- Open Data Institute
- Ordnance Survey
- Satellite Applications Catapult
- Royal National Institute of Blind People (RNIB)
- Thales Group
- The Insight Lab/Bionical
- The People for Change Foundation (Malta)
- The World Bank (USA)
- Transport Systems Catapult
- Unilever
- University College London
- University of Cambridge – Trustworthy Technologies SRI
- University of Southern Denmark
- Worcester Polytechnic Institute (USA)

CDT alumni

The Horizon CDT is extremely proud of the success it has achieved since its launch in 2009 and takes pride in the fact that graduates have left the CDT with not only a PhD, but with high-level doctoral skills, expertise, experience and knowledge to progress to professional careers around the world in a variety of sectors.

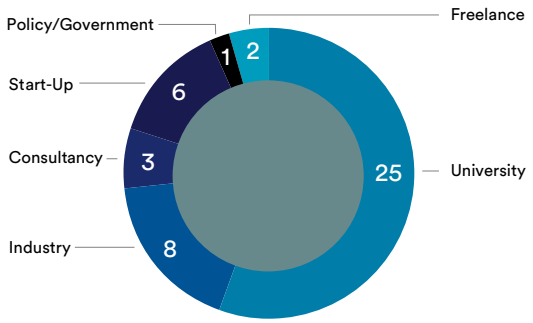
Horizon CDT has:

- **55 PhD thesis submissions to date**
- **50 PhD graduates**

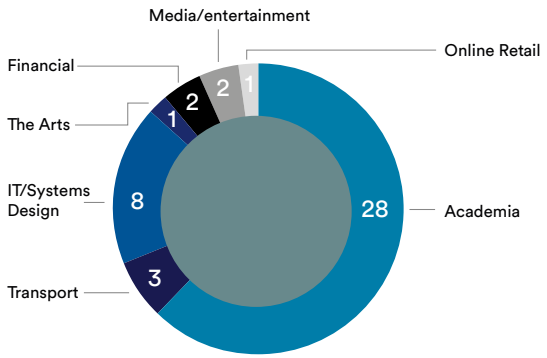
Examples of Horizon CDT alumni employers:

- Airbus
- Goldsmiths, University of London
- Jaguar Land Rover UK
- Methods
- Microsoft Research
- New York University
- Royal College of Art
- Sony Interactive Entertainment Europe
- The World Bank
- United Nations
- University of Edinburgh
- University of Leicester
- University of Nottingham

Employing organisation types of Horizon CDT graduates



Employing sectors of Horizon CDT graduates



International employment destinations of Horizon CDT graduates

Case study: Collaborating and giving back

Horia Maior (2012 cohort)

After graduating with a strong multi-disciplinary PhD in December 2017, Horia had the opportunity to develop new collaborations, attract industry partners, write proposals and secure research funding.

In 2017 Horia won the prestigious Engineering and Physical Sciences Research Council (EPSRC) Doctoral Prize Fellowship. The fellowship (approximately £70,000) facilitated support for a 2-year research agenda and the ideas as principal investigator. The winning proposal was "Brain-Tracker: A fit-bit for the Brain based on physiological sensors, tracking the mental workload of everyday tasks".

Horia's research has a strong multi-disciplinary nature, bridging together theoretical groundings from Human Factors, applied data science research in Computer Science, and evaluation techniques from Human-Computer Interaction.

Horia has developed world leading expertise on using brain and physiological data together with other quantitative and qualitative methods to learn more about the users during interaction. Evaluating users' cognitive capabilities plays an important role when designing technology that better incorporates users' needs and limitations. His long-term vision is focused on using less-invasive, more acceptable wearable technologies for tracking both physical and mental wellbeing in the wild. The impact of this work falls in line with the EPSRC's focus on a healthy and resilient nation. Wellbeing is concerned with both the body and the mind – at one end stress is directly associated with workload – at the other end, mental decline with age is associated with underload.

Alongside his research, Horia enjoys lecturing and supervising students. Between February and July 2017 he moved to the Nottingham University Ningbo campus in China on a short term Teaching Fellow Role in order to support the School of Computer Science teaching.

Apart from his academic track, Horia is also passionate about giving back and creating new opportunities for the community, and has built strong links with nearby charities in addition to the University of Nottingham and the Nottingham City Council. At the end of 2018 Horia co-founded "Inspire Foundation", a Nottingham based charity focused on helping and inspiring young people towards Science, Technology, Engineering, and Mathematics (STEM) subjects.

As part of the project "Victor Tudorica Bursary for education and development", a STEM Saturday Club for 11-14 year old's young people around Nottingham was created. Horia coordinates this project and a team of over 15 members and volunteers delivering STEM related workshops and activities. This project has been awarded one of the Public Engagement Grants from the University of Nottingham to further support outreach and community activities.

Case Study: Internet of Things in everyday objects

Martin Porcheron (2013 cohort)

Martin was a member of the 2013 cohort. His thesis, titled 'Understanding Conversation around Technology Use in Casual-Social Settings', examined the use of technologies such as smartphones and smart speakers while people are socialising. His PhD led to three publications, including one Best Paper award at the annual CHI conference – ranking among the top 1% of all submissions.

After completing the PhD programme, Martin secured an internal Horizon CDT Impact Grant which he used to share findings from his work with industry practitioners.

Since April 2018, Martin has been a Research Associate in the Mixed Reality Lab, using the skills he developed during his PhD on a range of projects including studying the social-technical matters surrounding the Autonomous Internet of Things, and the development of interactive systems for providing informal health advice in sub-Saharan Africa. Through collaboration with colleagues, he also continues to work on follow-on projects from his PhD.

Currently Martin is working on RoboClean, a jointly run project between the University of Nottingham Smart Products Beacon and Horizon Products Campaign. RoboClean is investigating the potential of human-robot collaboration, integrated with IoT smart sensors for cleaning and allergen detection on factory floors. The outcomes of this project will include the design, implementation, and evaluation of an interactive system that could clean factory floors alongside human workers, while performing on-line detection of allergens.

Horizon CDT thesis titles

Case study: Developing an academic career post doctorate training

Dr Chris James Carter (2010 cohort)

Dr Chris James Carter was awarded his PhD in December 2015 and is an Assistant Professor in Entrepreneurship & Innovation at the Haydn Green Institute for Innovation and Entrepreneurship (HGI), Nottingham University Business School. His thesis was entitled, 'Understanding the Professionally Risky Behaviour of Young Adults in Using Social Media'.

Since graduating from, Chris has worked closely with the Centre in a number of roles, including as a guest lecturer on the first-year Advanced Research Methods module, Practice-Led Project (PLP) supervisor, a Horizon CDT Impact Grant holder, and PhD supervisor for Christian Tamakloe (2016 cohort) and Kadja Manninen (2018 cohort).

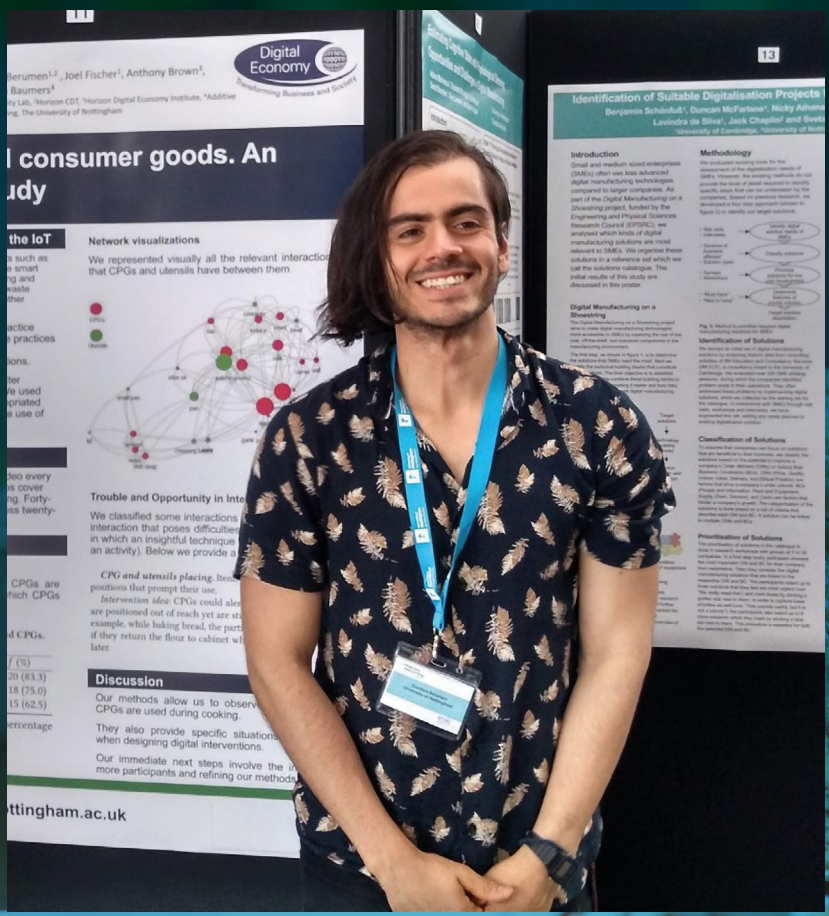
Following a successful PLP, Chris started a research project with Kadja and HGI colleague, Dr Hannah Noke, investigating entrepreneurial opportunity recognition amongst Instagram "influencers". Adopting an innovative approach to mixing big data analytics with traditional semi-structured interviews, the research team look forward to sharing some of their preliminary findings in July 2019 at the *DISCo! Digital Economy Summer School Conference*, hosted at the University of Nottingham.

Chris is also currently collaborating on a project led by Dr Angela Martinez Dy (Loughborough University London), evaluating the impact of the OneTech programme. Co-funded by Capital Enterprise and J.P. Morgan, this initiative aims to support underrepresented female and BAME tech founders in London. Chris and Angela are aiming to present initial findings at the Institute for Small Business and Entrepreneurship (ISBE) conference at Newcastle in November 2019.

This year has also provided Chris with exciting new opportunities to engage with initiatives based in Asia. In March, he was invited to be a keynote speaker and mentor at the Ingenuity19 *Tech for Good Summit* held in Cyberjaya, Malaysia. Chris was also recently appointed as Deputy Director of Entrepreneurship MSc Programmes for Nottingham University Business School and is co-editing a 2020 Special Issue of the International Small Business Journal (ISBJ) titled, 'Social Media and Entrepreneurship: Exploring the Implications for Entrepreneurial Processes and Outcomes'.

Case study: Psychology and Computer Science disciplines unite

Gustavo Berumen Salazar (2017 cohort)



Gustavo began the Horizon CDT programme in autumn 2017 after studying at the University of Guadalajara, Mexico. Gustavo's background is in cognitive psychology and his research experience is in cognitive neuroscience.

"I believe that my background gives me tools to attempt to understand people's behaviours, and that the research methods I learned could help me conduct further investigation into human and technology interaction.

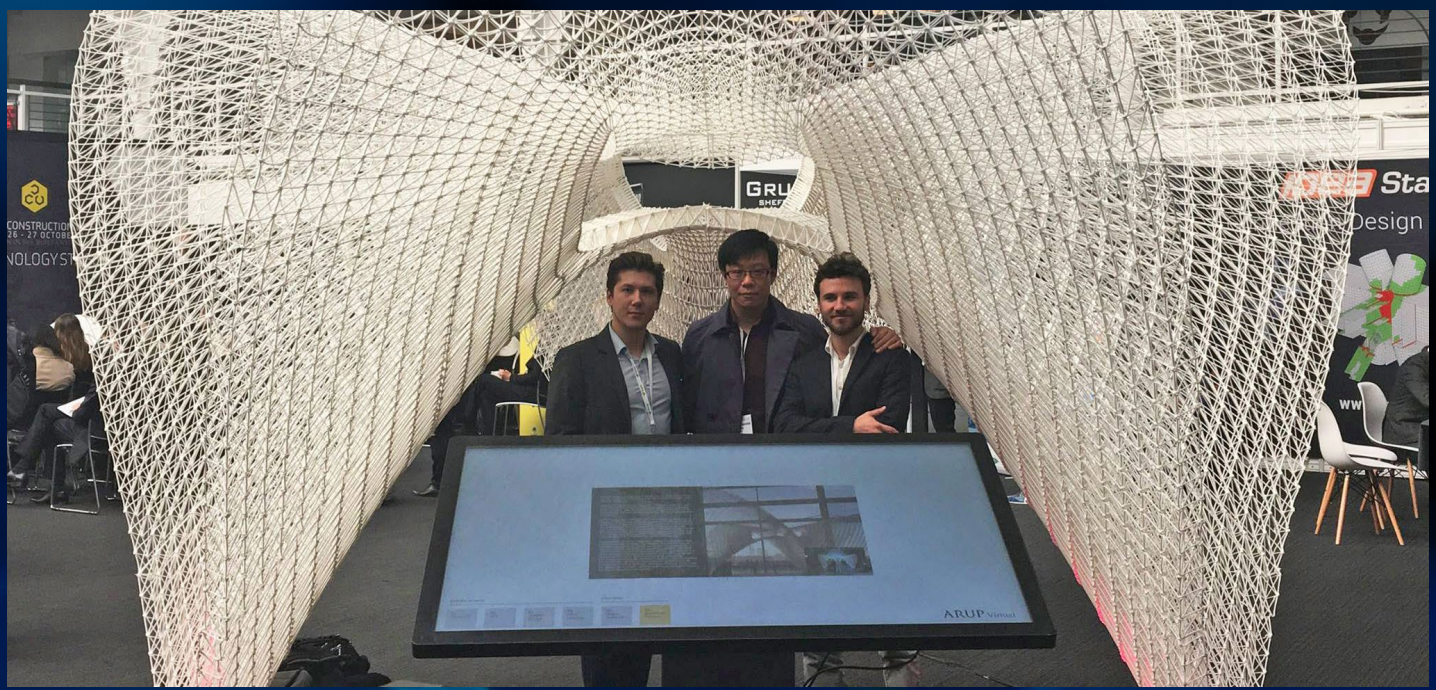
In my research project, we aim to develop smart versions of low-cost, disposable consumer goods such as packaged foods. The addition of technology to these products would allow them to provide digital services that could help them to cater to people's needs better.

We endeavour to create smart consumer products that aid us in issues that we, as a society, consider important such as helping us to have a healthier diet and use more sustainable goods and energy.

Using a design ethnography approach to study cooking, we have identified areas of opportunity to improve consumer goods and enhance the cooking experience. Our next steps include developing prototypes of smart consumer goods and testing their effectiveness in the field."

Case study: Coding to simulate nature's patterns

Feng Zhou (2017 cohort)



Feng commenced his Horizon CDT PhD programme in October 2017 after working on computational design and digital fabrication by robotic arm at University College London and London South Bank University. Many projects that Feng has lead or participated in have been showcased at Milano Design Week, Centre Pompidou and at the Zaha Hadid Design Gallery. These projects were designed by natural code which simulates pattern or behaviour from nature to achieve organic and graceful design.

One of Feng's PhD research targets is to achieve automatic customised aesthetic designs by various tools e.g. dance or music rather than pen or software for designers, specifically customising very unique and specific aesthetic patterns applied on amputated dancer's artificial limbs by their own dancing motions. The design could be as unique as an individual's genes or finger prints. It can even be seen as unique jewellery to show an individual's taste and personality.

Feng is also working on six-axis 3D printing technology in order to reduce the mechanical property limitations on aesthetic design.

Case study: Developing a tool to support navigation aid designers

Ziyad Yehia (2015 cohort)

Ziyad Yehia began his Horizon CDT PhD programme in 2015 after completing a Master's in Mechanical Engineering at the University of Nottingham.

Ziyad's work is in collaboration with the Guide Dogs charity and focuses on how navigation aid design can be improved to enhance the independence of the visually impaired.

Ziyad has produced a novel card-based design tool to help navigation aid designers offer "on the table" important concepts that should be considered when designing new navigation aids.
Ziyad's cards will provide two main benefits:

1. Relevant, research-backed content to ideate with
2. A fun, game-like structure to the design sessions

By providing designers with a rich repository of research-backed concepts, and structuring the use of that repository in the form of a card game, the Blind Nav Cards help navigation aid designers to consider a wide range of important concepts. The game-like structure helps them to employ academic research in a way that is compatible with a creative environment. In turn, this will help designers to take a more comprehensive and holistic view of the needs of the visually impaired when designing aids. It is hoped that use of the Blind Nav Cards will result in an improved design quality of navigation aids, and, ultimately, to an improved life quality for the visually impaired.

Horizon CDT invests in responsive impact grants for PhD research

In Autumn 2017, the Horizon Centre for Doctoral Training invested in ten responsive impact grants for Horizon CDT students and alumni, in order to facilitate the extension and acceleration of the impact of their research.

These awards were open to Horizon CDT students and alumni only, and designed to support the first investigative steps of taking EPSRC-funded research carried out within the CDT and associated research groups towards commercialisation, or on to other forms of economic, societal, environmental and policy-based impact.

After a competitive application process, the project titles and awardees of the internal impact funding were as follows:

- Examining the big data produced through student use of the Ingenuity Online platform (Dr Chris Carter, 2010 alumnus)
- Creating a content creation, presentation and sharing platform using adaptable Photogrammetry 3D scanning technology to create 3D models of physical objects (Dr Dimitri Darzentas, 2012 alumnus)
- Trust and calibration of trust in Connected and Automated Vehicles (George Filip, 2013 cohort)
- Dynamic musical listening experiences that respond to spatial exploration (Dr Adrian Hazzard, 2010 alumnus)
- Investigating the digital economies that emerge from video game contexts (Dr Panos Koutsouras, 2013 cohort alumnus)
- How the convergence between theatre for early years and digital technologies can make performances more multi-sensory, playful, participatory and interactive. (Roma Patel, 2013 cohort)
- Development of Amazon Echo usage in the home audio data for use as an open dataset online. (Martin Porcheron, 2013 cohort)
- How people can interact with a brain-controlled film both actively and passively using their mind (Richard Ramchurn, 2015 cohort)
- Pain assessment in newborns using new data collection techniques. (Dr Mercedes Torres Torres, 2010 alumna)
- Engagement through play: Investigating the relationship between video games and political engagement (Hanne Wagner, 2013 cohort)

You can find out more about the acivities and outcomes from these projects by visiting the Horizon CDT website at **cdt.horizon.ac.uk/impact**.

Case Study: Wearable technology to track our emotions

Marie Dilworth (2017 cohort)

Marie Dilworth is a user researcher and computer scientist based in the University of Nottingham's Mixed Reality Lab. She began a PhD partnership with the Nottingham Biomedical Research Centre's Mental Health Theme in 2017. Marie's research investigates how daily activities, emotional experience and non-verbal communication might be captured using on-the-body technology, potentially enabling wearers to gain insight into their emotionally rich inner lives.

Combining the apparently disparate fields of electronics, computer science, machine learning, smart textiles, dressmaking and movement analysis has enabled Marie to construct a smart t-shirt that captures data about body pose and movement. Marie's research will investigate the relationship between this data and the wearer's emotional experience.

Emotion tracking from movement could have interesting applications in the fields of mental health and wellbeing. By tracking emotional states over hours, days and weeks it might be possible for wearers to better understand their emotions and make positive life changes.

Case Study: CDT alumni pursues academic career at Horizon, University of Nottingham

Dr Liz Dowthwaite (2012 cohort)

You can find out more about Liz's research at
uyj.wp.horizon.ac.uk
unbias.wp.horizon.ac.uk/fairness-toolkit

Liz submitted her PhD thesis, entitled "Crowdfunding Webcomics: The role of incentives and reciprocity in monetising free content" in September 2017 and graduated in July 2018. Since 2016 she has been a Researcher at Horizon Digital Economy Research, predominantly working on the UnBias and ReEnTrust projects.

Both projects look at the effects of algorithm-mediated online content, for example social media and search engine results, on the user. Liz worked with young people aged 13-17 to understand their concerns, and was involved in the creation of an Open Educational Resource, and Fairness Toolkit which included a set of Awareness cards designed to teach people about the issues they might face. This led to an Impact Acceleration Grant which allowed testing the cards with a broad range of people and come up with a series of fun and educational games. On ReEnTrust she is involved in running workshops with young and older adults to understand how trust affects their online experience.

As well as these projects, Liz works across a variety of other Horizon projects, including In My Seat, which examines user experience of journeys and relationships with place, and Personal Understanding of Data, which aims to explore people's mental models of personal data. She also teaches on CDT modules and co-supervises a CDT student. She actively pursues her own research interests, based on her background in Psychology and Human Factors, looking at attitudes and motivations for participation in online crowds (for example citizen science, crowdsourcing, and crowdfunding), and how these relate to concepts such as reciprocity, personal needs and values, and wellbeing.

Case Study: Video-based pain assessment in newborn infants

IDIC Cohort 2013

Joy's PhD research focused on developing automated tools for pain assessment in patients incapable of self-reporting pain, e.g., newborn infants and unconscious patients, using computer vision and machine learning techniques. Though pain assessment is a crucial part of medical treatment, current assessment practices in Intensive Care Units (ICUs) do not support continuous pain monitoring and are highly subjective. Joy's research produced automated pain assessment tools which continuously assess patients' behavioural changes (e.g. facial expressions and body movements) and provides real-time feedback to medical personnel, thus supporting decisions on medical treatment.

In 2017, having successfully developed two methods for automatic pain assessment in adult patients, Joy's research, in collaboration with Dr Mercedes Torres Torres was awarded the Horizon CDT Research Impact Grant to extend this work to newborn pain assessment. This project involved the collection of video recordings of babies undergoing painful/painless medical procedures at the National Hospital, Abuja, Nigeria and resulted in three major achievements:

i. The development of an automated newborn pain assessment tool which produced results comparable to manual assessment by experienced Neonatal ICU nurses.

ii. The creation of an 11-point Neonatal Face and Limb Acute Pain Scale (NFLAPS) specifically suited for computer vision technologies, unlike existing medical scales which use parameters that are not assessable by these technologies.

iii. An Acute Pain in Neonates database (APN-Db) containing over 250 video recordings of various medical procedures together with NFLAPS pain annotations for each video, scored by experienced Neonatal ICU nurses. This database would assist computer vision researchers in developing more efficient automated newborn pain assessment tools and consequently lead to improved infant health care.

Joy submitted her PhD thesis "Automatic Pain Assessment from Face Video (Continuous Pain Estimation in Adults and Neonates)" in 2018 and graduated in March 2019. She is now a Research Fellow in the Computer Vision Lab of the School of Computer Science.

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