connected everything.

industrial systems in the digital age

2018 Conference:
Manufacturing a Brave New World

Tuesday 26 and Wednesday 27 June 2018

Urban Sciences Building

Newcastle University

EPSRC
Engineering and Physical Sciences Research Council

Newcastle University
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Welcome Message

Dear Colleague,

On behalf of the organisers of “Manufacturing a Brave New World”, I warmly welcome you to the second annual conference organised by the Connected Everything network.

It is being hosted here in the Urban Sciences Building [UBS], the new home of Newcastle University’s School of Computing. Opened in September 2017, the building and its surrounding city area is a living laboratory underpinning research to make urban centres more sustainable for future generations.

The USB is a demonstrator for understanding the relationship between buildings and their wider environment. The thousands of sensors located in the building make it possible to not only understand its performance, but also how it interfaces with the energy, water, internet and other networks it is connected to. By co-locating computer scientists with engineers, we are leading new research that explores the crucial dependencies much of our infrastructures have on digital technology e.g. cyber security of buildings. We will have a talk on this as part of the conference programme

We are fortunate that the conference is taking place at the same time as the Great Exhibition of the North, a free, summer-long celebration of the North of England’s pioneering spirit. As part of the exhibition, Robert Stephenson’s iconic locomotive Rocket has come home to Newcastle, on loan to Discovery Museum from the Science Museum Group. We will be able to see this iconic exhibit close up at the drinks reception prior to the conference dinner.

I hope you enjoy your visit to Newcastle.

Professor Paul Watson

School of Computer Science

Day 1	Tuesday 26 June 2018
10:00—10:30	Registration: foyer of the Urban Sciences Building
10:30—10.45	**Welcome address** Professor John Fitzgerald, School of Computer Science, Newcastle University
10.45—11.30	**Keynote 1** **IoT 4 MFG** Professor Thomas Kurfess, Georgia Tech
11.30—13.00	**Session 1: Industry perspectives on digital disruption** JP Sherlock (Astra Zeneca) Professor Iain Todd (MAPP) Dave Elliott (Holovis) Paul Hingley (Siemens) Panel session
13.00—14.00	*Lunch and networking, Poster Presentations*
14:00—15:30	**Session 2: Connected Everything Feasibility Studies**
	Automatic Fault Detection for Selective Laser Melting using Semi-Supervised Machine Learning Peter Green, University of Liverpool **Investigating Spoken Dialogue to Support Manufacturing Processes** Rob Gaizauskas, University of Sheffield **BREWNET: Intelligent cloud connected sensors for economic small scale process optimisation** Nik Watson, University of Nottingham, and Ali Zaidi, University of Leeds **Circular 4.0: Digital intelligence to enable a circular economy** Windo Hubarat, Cranfield University **Feasibility of capturing crafts-based knowledge in an AI System for future autonomous precision surface manufacturing** David Walker, University of Huddersfield
15:30—16:00	*Break and refreshments, Poster Presentations*
16:00—17:00	**Session 3: The Responsive Supply Chain**
	Digitally Enabled Supply Chains David Butler, National Physical Laboratory **Collaborative Design of Supply Networks** Nikolay Mehandjiev, University of Manchester **Sensor City – Inside a Global Innovation Hub** Alison Mitchell, Sensor City
17.00	*Day 1 close*
19:00	**Conference dinner at Discovery Museum** Drinks reception followed by the conference dinner

Day 2	Wednesday 27 June 2018
09.30—10.15	**Session 4: Digital Manufacturing and the Industrial Strategy**
	Katie Daniel, EPSRC
10.15—11.30	**Workshop session:**
	Research challenges and the Industrial Strategy
11.30 – 11.45	*Break and refreshments, Poster Presentations*
11.45—12.45	**Keynote 2**
	Scale-up of a reactive chemical process utilising Continuous Oscillatory Baffled Reactor (COBR) technology from laboratory to multi-ton pilot scale manufacturing James Birbeck, Croda International
12.45—13.45	*Lunch and networking, Poster Presentations*
13.45—14.15	**Session 5: Design for future manufacturing**
	The [re]Definition of Design Fiona Charnley, Cranfield University **Resilient Trans-Disciplinary Design Engineers Platform** Alex Kharlamov, University of the West of England
14.15—14.45	**Session 6: Cybersecurity**
	Assessing the Security of Smart Buildings Charles Morriset, Newcastle University **The unexpected security consequences of cats, flaps and programming mishaps** Leigh Chase (IBM)
14.45—15.45	**Keynote 3 and Open Discussion**
	Hybrid Products Professor Steve Benford, University of Nottingham
15.45—16.00	**Closing Remarks**
	Professor Paul Watson, Newcastle University Best Paper Award, by Professor Hongnian Yu, Bournemouth University (Programme Chair)
16.00	*Conference Close*

Day 1—Conference Welcome

Professor John Fitzgerald
Head of the School of Computing
Newcastle University

John Fitzgerald is a specialist in rigorous model-based design techniques for the design of cyber-physical systems and systems-of-systems. He has been leading for the School on the design of the Urban Sciences Building - the first major university building at Newcastle Science Central - a new home for all our research and teaching activities from autumn 2017. John has served as Director of Research (to 2015), Director of the Centre for Software Reliability, and Deputy Head (to 2017) of the school of Computing. Since August 2017, he has been Head of the newly constituted School of Computing.

John studied formal proof (PhD, Manchester Univ.), before joining Newcastle University, where he worked on design techniques for avionic systems with British Aerospace in the 1990s. He went on to study the potential for industrial application of formal modelling (specifically the Vienna Development Methods - VDM) as a SERC Fellow and later as a Lecturer at Newcastle. He established the design and validation team at Transitive, a successful SME in the embedded processor market before returning to the University in 2003.

John recently completed a decade as Chair of FME, the main European body bringing together researchers and practitioners in rigorous methods of systems development. He is a Fellow of the BCS, and a member of the EPSRC College, the ACM, IEEE and INCOSE.

Day 1—AM Keynote Session

Thomas Kurfess
Professor and HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

IoT 4 MFG

Sensors are ubiquitous in modern manufacturing operations, and they generate significant quantities of data. With the advent of low cost, readily available broad band communication and virtually infinite cloud storage, many of the old stigmatisms related to taking data from a plant are no longer of concern. However, the question still remains as to what to do with the data.

This lecture will discuss the use of large scale data sets from production operations and how they can be leveraged to better understand not only traditional operations, but untapped opportunities from data that are readily available today. Such opportunities provide an improved platform for classical analytic techniques as well as more modern, data intensive approaches to process and operations modelling. The talk will then focus on a specific next generation digital representations and their application to low cost, highly flexible implementations. Examples will be given for both manufacturing operations (additive and subtractive) and validation/verification, as well as how this capability is extensible to cloud computing operations, and next generation technology and business models such as Desktop as a Service (DAAS). The talk will conclude with a discussion of the technology, workforce and infrastructural directions and needs to fully enable the next generation digital twin, and where such a capability will drive the future of manufacturing.

Professor Kurfess' research focuses on the design and development of advanced manufacturing systems targeting complex product production and optimization. He has significant efforts underway in advanced and high precision manufacturing and metrology systems, as well as national and international manufacturing policy issues.

Professor Kurfess served as the Assistant Director for Advanced Manufacturing at the Office of Science and Technology Policy in the Executive Office of the President of the United States of America. In this position he had responsibility for engaging the Federal sector and the greater scientific community to identify possible areas for policy actions related to manufacturing. He was responsible for coordinating Federal advanced manufacturing R&D, addressing issues related to technology commercialization, identifying gaps in current Federal R&D in advanced manufacturing, and developing strategies to address these gaps.

Day 2—Keynote Session

Dr James Birbeck
Lead Process Engineer
Croda International

Scale-up of a reactive chemical process utilising Continuous Oscillatory Baffled Reactor (COBR) technology from laboratory to multi-ton pilot scale manufacturing

James Birbeck went to University in Sheffield gaining a MEng in Chemical Engineering and Chemistry in 2006. He earned a PhD in Chemistry in 2011 also from Sheffield University under the supervision of Dr Anthony Haynes studying the effects of phosphine ligands on the reactivity of cobalt acyl complexes for catalytic hydroformylation, industrially sponsored by Sasol. James started at Croda in 2010 initially on a rotational graduate scheme before joining the Process Innovation Team at the end of 2012 working as an engineer.

Since then James has been involved with a number of technical development and scale-up projects in areas such as filtration, separation, mixing, process intensification and continuous processing. In the past three years, he has focussed on scale-up of a reactive chemical process utilising NiTech’s patented Continuous Oscillatory Baffled Reactor (COBR) technology to intensify the manufacture process for a number of key products.

Day 2—Keynote Session

Professor Steve Benford
Professor of Computer Science
The University of Nottingham

Hybrid Products

Digital technologies are transforming the nature of products. Complex high-value products routinely include software to make them adaptive, autonomous, connected and even intelligent. At the other end of the scale, fast moving consumer goods generate digital footprints as they are produced, distributed and consumed, feeding personal data back into the production process. In turn, augmented reality overlays digital media on physical goods to deliver blended product experiences to consumers. In short, our products are increasingly hybrids of physical and digital materials and functionality.

My talk will draw on examples of design-led research – from an acoustic guitar that carries its own digital history to a paper advent calendar that can be digitally customised – to illustrate the increasingly hybrid nature of everyday products. I will explore how this hybridity blurs traditional distinctions between goods, services and experiences and establishes new relationships between producers and consumers that involve customisation and co-creation. I will also set out some of the cross-disciplinary challenges that we must overcome if we are to enter this 'brave new world' of hybrid products.

Steve Benford is Professor of Collaborative Computing at the Mixed Reality Laboratory at the University of Nottingham. His research interests span creative and cultural applications of computing, from interactive art to mainstream entertainment, with a particular focus on new interaction techniques. He has established an international reputation for working with artists to create, tour and study interactive performances that have garnered international acclaim, led to award winning papers and also fed into mainstream entertainment through collaborations with major companies from Sony to the BBC.

Steve's research has fuelled the emergence of new cultural forms such as pervasive games and mixed reality performance, while also delivering foundational principles for user experience design, most notably his work on trajectories, uncomfortable interactions, spectator interfaces and most recently the hybrid craft of making of physical-digital artefacts.

Day 1—Feasibility Studies

Automatic Fault Detection for Selective Laser Melting using Semi-Supervised Machine Learning

P.L.Green[1], K.Black[1] and C.Sutcliffe[1,2]

[1]University of Liverpool, [2]Renishaw

Risk-averse disciplines such as the medical, aerospace and energy sectors have been somewhat slow towards accepting and applying Additive Manufacturing (AM) in many of their value chains. This is partly because there are still significant uncertainties concerning the quality of AM builds. This talk introduces a machine learning algorithm for the automatic detection of faults in AM products. The approach is semi-supervised in that, during training, it is able to use data from both builds where the resulting components were certified and builds where the quality of the resulting components are unknown. This makes the approach cost efficient, particularly in scenarios where part certification is costly and time consuming.

The study specifically analyses Selective Laser Melting (SLM) builds. Key features are extracted from large sets of photodiode data, obtained during the building of 49 tensile test bars. Ultimate tensile strength (UTS) tests were then used to categorise each bar as 'faulty' or 'acceptable'. A fully supervised approach identified faulty specimens with a 77% success rate while the semi-supervised approach was able to achieve the same results, despite being trained on a fraction of the available certification data.

Day 1—Feasibility Studies

Investigating Spoken Dialogue to Support Manufacturing Processes

R.Gaizauskas, E.Barker and J. Law

University of Sheffield

Across the industrialised world there is broad agreement that we are on the brink of revolutionary changes in manufacturing, brought about by the convergence of industrial production and information and communication technologies. Amongst the many emerging capabilities envisaged to form part of this revolution are: (1) human-robot co-working, where the complementary strengths of humans and robots in industrial settings are exploited to deliver performance superior to that achievable by either humans or robots on their own, and (2) intelligent decision support, where human factory workers, no longer simply machine operators, are supported by rich information systems in making decisions, e.g, to address unforeseen problems or maintain or reconfigure industrial processes.

Developing these capabilities and integrating them into the work environment is a key part of delivering the Industry 4.0/"factory of the future" vision. Core to both human-robot co-working and intelligent decision support is communication between humans and machines, whether the machines be robots or information systems. Human-machine communication may take many forms and it is not straightforward to determine, in a given setting, which form human-machine communication should take and this is particularly true in manufacturing environments.

Rapid technological change is giving machines new communicative capacities whose potential needs to be explored. More importantly, in a given work setting our very understanding of the tasks and how they may be divided between human and machine is based on assumptions about the form of, and limitations on, communication between the two. New forms of communication may enable new, more effective ways of working. Our hypothesis, which we propose to investigate in this feasibility study and beyond, is that spoken natural language dialogue has the potential to be uniquely effective and enabling as means of communication between humans and machines in manufacturing environments, specifically for human-robot co-working and for decision support, and that it is now a mature enough technology to be exploited in these environments.

This feasibility study aims is to produce an evidence-based assessment of the potential for spoken dialogue systems (SDS) in human-robot co-working and intelligent decision support in real manufacturing environments, identifying specific scenarios where SDS would be useful, determining requirements on those systems, assessing the extent to which existing technologies may be sufficient and where research challenges may lie, and laying the groundwork for future work in this area.

Day 1—Feasibility Studies

Feasibility of Capturing Crafts-based Knowledge in an AI System for Future Autonomous Precision-Surface Manufacturing

D.Walker[1], A. P. Longstaff[1], S. Parkinson[1], W. Pan[1], S. Petrovic[2], P. Ward[1] and K. Wilson[1]

[1]University of Huddersfield, [2]The University of Nottingham

The manufacture of precision and ultra-precision functional surfaces for optical, medical and engineering products embraces many artefacts (e.g. optics, prosthetic joint implants, moulds and dies) and several strategically-important sectors, from consumer products, through healthcare, aerospace and automotive, to defence and space. It is remarkable just how much craft-based hand-work is still used in these extremely high value industries, e.g. had-lapping of optics, precision moulds & dies etc. Whilst this is progressively giving way to CNC machines, these are still highly-dependent on craft expertise to optimise the results. This may involve know-how in special techniques for different materials and surface-forms. Then, crafts-input will be required in interpreting measurement results, and then for planning the right approach to remedy particular surface features that arise, or resolve unexpected process anomalies. Unfortunately, this know-how is being permanently lost as expert craftspeople retire.

This project has a vision of an adaptive Autonomous Manufacturing Cell for iterative precision surface-fabrication. Artificial Intelligence (AI) is the next key step in practically reducing and eventually eliminating human interventions, both in planning the initial strategy for processing some specific industrial component, and then in interpreting measurement data and adaptively planning each successive process-step. AI should also recognise and respond to unexpected process events, and finally determine when the part has reached specification. To achieve this, this will require a basic feedstock of digitally-accessible, high-quality information. This feasibility study is an essential building block for the ultimate vision of the autonomous manufacturing cell.

The aim of this project is to establish the feasibility, and a workable methodology, for capturing and encoding craft-expertise in a real-life iterative manufacturing context, then to define how optimally to archive it and present it as an accessible input to a future AI system within a future autonomous manufacturing cell.

Day 1—Feasibility Studies

Brewing the Perfect Beer: Is the Internet of Things an essential ingredient?

N.J.Watson[1], S.A.R.Zaidi[2], M. Harfeez[2] and J Escrig Escrig[1]

[1]The University of Nottingham, [2]University of Leeds

The food and drink industry is characterised by high volume production of low value products. SMEs operating within this sector often fall behind with technological advances due to a lack of capital to invest in new assets and limited or non-existent research capabilities. However digital manufacturing does not require expensive new hardware or onsite expertise as process benefits such as reduced costs, resource utilisation and waste are delivered via the collection, analysis and decision support capabilities of data. This data can be collected by low cost sensors which are connected to a cloud server for near real-time predictive analytics. One example of small scale food and drink processing is craft brewing.

In this talk, we will discuss our experience in developing a low-cost cloud-connected solution for fermentation process analytics. We will demonstrate how such solutions are applicable more broadly and outline some of the technical challenges in design, implementation and deployment of proposed solutions. Lastly, we would reflect on evolution trajectory for the Internet-of-food-things.

Day 1—Feasibility Studies

Circular 4.0: Digital Intelligence to Enable a Circular Economy

F.Charnley[1], A.Tiwari[2], M.Moreno[1] and W.Hutabarat[2]

[1]Cranfield University, [2]University of Sheffield

Digital Intelligence is rapidly becoming a pervasive feature of our economy, where data generated through social-, mobile-, machine- and product-networks are being leveraged through data analytics to create new forms of value. In manufacturing industries, through emerging concepts such as Industry 4.0 and IoT, Digital Intelligence is expected to transform how products are manufactured, sold, used and retained within the value chain.

A Circular Economy (CE) is an inherently feedback-rich system and Digital Intelligence can provide information feedback throughout a product's life, opening up opportunities for enhanced repair, reconditioning and re-manufacture. A key challenge is therefore to understand how such opportunities can be enabled for restorative and regenerative CE through application of Digital Intelligence and how the systemic impact of its implementation can be measured and up-scaled.

This feasibility study will investigate how data, acquired through the latest advances in digital technologies can provide Digital Intelligence to shape decisions about the manufacture and utilisation of automotive components for accelerating the implementation of more circular approaches in UK manufacturing. The novelty of this research lies in investigating the application of Digital Intelligence through the lens of a restorative circular economic (CE) model focusing on product life extension and its suitability at a particular point in a product's life cycle. This study will aim to demonstrate how service data, acquired through the application of digital technologies, can inform decisions surrounding the implementation of circular strategies, particularly product life extension.

Day 1—Session 3

Collaborative Design of Supply Networks

Nikolay Mehandjiev

University of Manchester

The vision of smart manufacturing invariably includes highly responsive supply chains enabling personalised products and small lot sizes. To implement this vision, we need to support the collaboration between companies aiming to set up or adapt a supply network. Providing such support is the aim of the EC-funded project DIGICOR[1], which develops a platform to facilitate such collaborations when companies respond to invitations to tender in the aerospace and automotive industries. The talk will use the context of the DIGICOR project to present the concept and the method of collaboratively designing a supply network through a shared model of the collaboration, which balances flexibility and control, and allows reconfiguration of the supply network when necessary.

[1]https://www.digicor-project.eu/

Day 1—Session 3

Sensor City – Inside a Global Innovation Hub

Alison Mitchell

Sensor City

The presentation will cover:
- Overview of Sensor City
- Adoption of IoT
- Industry applications of IIoT

Day 2—Session 4

Digital Manufacturing and the Industrial Strategy

Katie Daniel

Head of Manufacturing, EPSRC

This talk will provide an overview of the Made Smarter Review and proposed sector deal, the North West pilot and the development of the Industrial Strategy Challenge Fund (ISCF) Wave 3 digital manufacturing proposal. It will be followed by a workshop session digging deeper into the proposed research challenges, outlined in the ISCF Wave 3 proposal.

Day 2—Session 5

The [re]Defintion of Design

Fiona Charnley

Cranfield University

Dr Fiona Charnley joined Cranfield University as a Lecturer in Sustainable Product and Service Design in 2011 after working as a research fellow at De Montfort University where she managed an EPSRC funded project to engage school communities in sustainable design principles. This role involved working with multiple stakeholders from primary and secondary school pupils, teachers and governors through to designers and architects on the UK Government's Building Schools for the Future initiative.

Dr Charnley completed her PhD at Cranfield University in 2008 which focused on the factors that enable and inhibit the process of whole system design for the development of more innovative and sustainable products, services and systems. Working with a consortium of companies she conducted a longitudinal case study following the system level design of the Morgan Lifecar. Fiona has an MSc by research from Cranfield University in which she investigated the cognitive problem solving abilities of design engineers and a BA (Hons) in Industrial Design and Technology from Loughborough University.

Day 2—Session 5

Resilient Trans-Disciplinary Design Engineers Platform

Alex Kharlamov

University of the West of England

Dr Alex Kharlamov is a research fellow currently working at the cutting edge of IoT and business model thinking, part of a multi-university research team (Cambridge, Warwick, Surrey and UWE) on the EPSRC Hub of All Things Living Lab project. Hub of All Things (HAT) is an enabler for personal data collection and use. The focus is on Trust, Identity, Privacy and Security (TIPS) in the Digital Economy, centred on understanding and measuring user's perceived vulnerability to TIPS issues.

Parallel areas of work include behavioural operations (decision-making, errors and biases, individual differences in planning), supply chain segmentation and integrating analytics in operations management.

Day 2—Session 6

Assessing the Security of Smart Buildings

John Mace[1], Dr Charles Morisset[1], Carsten Maple[2], Hugh Boyes[2] and Tony Williams[3]

[1]Newcastle University, [2]University of Warwick, [3]Cube2 Ltd

Smart buildings contain highly connected systems automatically managing services such as heating, lighting, airflow and access control which are critical for smooth building operations. Automated building management systems improve productivity, health, safety, sustainability and energy consumption while their connection to the Internet and other data networks enables centralised, remote and more efficient monitoring, control, and maintenance. The progressive connectivity of these once isolated systems exposes them to a multitude of potentially damaging, disruptive and life-threatening cyber threats.

In 2017, we started the Newcastle Urban Sciences Building IoT (NUSBIoT) project, as part of the PETRAS Internet of Things Research Hub. The main goal was to investigate the security of smart buildings, taking as a case study Newcastle University's new, technically advanced, Urban Sciences Building (USB) which has been designed and built as an urban living laboratory and contains a wide range of connected building systems comprising multiple sensors and data collecting devices.

This talk will give an overview of the NUSBIoT's project objectives and outcomes which includes a security assessment and architectural review of the USB's building management systems, and a proof of concept threat modelling study to support the analysis of emerging security threats to smart buildings. The talk will then highlight NUSBIoT's key learnings and recommendations that could inform future building design decisions regarding the measures and controls needed to strengthen the security of smart buildings similar to the USB.

Day 2—Session 6

The unexpected security consequences of cats, flaps and programming mishaps

Leigh Chase

IBM

Leigh is a Computer Scientist and leads the Security Intelligence & Operations Consulting competency for IBM Security, UK & Ireland. Within this role he leads the development of new tools and techniques for security intelligence gathering, processing and reporting. Leigh's wider experience includes ethical hacking, solution design and engineering; consequently, he takes a practical view of what can really make a difference to systems owners, operators and integrators.

Day 2—Closing Comments

Professor Paul Watson

Director of the Digital Institute, Professor of Computer Science
Newcastle Univeristy

Paul Watson is Professor of Computer Science and Director of the Digital Institute at Newcastle University. A Co-Investigator of Connected Everything, Paul is also PI of the EPSRC Centre for Doctoral Training in Cloud Computing for Big Data and previously directed the £12M RCUK-funded Digital Economy Hub on Social Inclusion through the Digital Economy which focussed on using advanced computing technologies to transform the lives of older people and those with disabilities. He graduated in 1983 with a BSc in Computer Engineering from Manchester University, followed by a PhD on parallel computing in 1986. In the 80s, as a Lecturer at Manchester University, he was a designer of the Alvey Flagship and Esprit EDS systems. From 1990-5 he worked for ICL as a system designer of the Goldrush MegaServer parallel database server, which was released as a product in 1994.

In August 1995 he moved to Newcastle University, where he has led a range of research projects. His research interest is in scalable information management with a current focus on Data Analytics and IoT. He sits on the board of Dynamo North East, an industry-led organisation created to grow the IT economy of the region. He is also a member of the Department for Transport Science Advisory Council. Professor Watson is a Fellow of the Royal Academy of Engineering, a Fellow of the British Computer Society, a Chartered Engineer and a member of the UK Computing Research Committee. He received the 2014 Jim Gray eScience Award.

Poster Presentations

Continuous In Situ Microstructure and Composition Analysis within 3D-Printed Structures Using In-Chamber Sensors

Phillip Stanley-Marbell[1], Robert Hewson[2], Daniela Petrelli[3] and Nick Dulake[3]

[1]University of Cambridge, [2]Imperial College London, [3]Sheffield Hallam University

Microstructure and composition variations in the materials of manufactured objects dictate their aesthetic and functional properties. Information about millimeter-scale variations in composition and in the rheology of precursor materials during manufacturing a specific part, would provide a unique fingerprint for each instance of a product. This information would enable more accurate estimation of product quality, would enable dynamic adaptation of the manufacturing process to properties detected during the manufacturing process, and more.

Recent work has begun to investigate developing machine learning algorithms to use information on powder bed temperature variations to predict the structural properties of manufactured parts. Despite the potential value of millimeter-level per-part-layer microstructure and chemical composition data, today, no cost-effective and pervasive methods exist for low-cost implementation of characterization in the manufacturing process, beyond, say, temperature measurements.

This work investigates new approaches for continuous in situ microstructure and composition analysis within the SLS process. Our mission is to understand the process by which we could extend the traditional SLS chamber components with microstructure and materials composition sensors and in situ data analysis.

Poster Presentations

Reliability Analysis Using Deep Learning and Semi-supervised Techniques

Chong Chen and Ying Liu

Cardiff University

Over the last few decades, reliability analysis has gained more and more attention as it can be beneficial in lowering the maintenance cost. Time between failures (TBF) is an essential topic in reliability analysis. If the TBF can be accurately predicted, preventive maintenance can be scheduled in advance in order to avoid critical failures.

The purpose of this paper is to research the TBF using deep learning techniques. Deep l earning, as a tool capable of capturing the highly complex and non-linearly patterns, can be a useful tool for TBF prediction. Furthermore, as the large sum amount of the real-world labelled data is hard to obtain, the semi-supervised learning approach has also been explored so that eventually an integrated approach for reliability analysis is targeted in this study.

Poster Presentations

Immersive virtual reality teleoperation

Daniel Brice and Karen Rafferty

Queen's University Belfast

There is a growing need for teleoperation in manufacturing due to the continued working in hazardous environments, an aging workforce and an increased prevalence of robots in manufacturing environments. Current models for teleoperation utilise expensive hardware and software packages, whilst still requiring a skilled individual for operation. Here a relatively low cost teleoperation model is proposed utilising a domestic Virtual Reality (VR) technology, a 3D camera and Rethink Robotics' Baxter robot operating on Robot Operating System (ROS). The system aims to provide users with a more intuitive way of performing teleoperation, one where a non-expert is able to walk around the robot and perform operations in a 3D virtual environment. The user is immersed in a virtual representation of the work scene, attained from 3D scanning the environment beforehand. The system then maps objects such as the Baxter robot and a tracked work item from the real world into the virtual environment. Additionally camera feeds of the scene are viewed from the virtual environment to enable real world visual feedback as an aid for virtual representation.

This work demonstrates the feasibility of such an immersive system through ongoing testing to evaluate the capabilities of remotely performing assembly tasks. Suggested future work entails the addition of haptics to the system. This will aid the visual feedback in conveying the end effector proximity to boundaries, as well as Baxter's reachability.

Poster Presentations

Multi-Sourced Data Analytics for AM Energy Consumption Prediction

Jian Qin and Ying Liu

Cardiff University

It is well-known that additive manufacturing (AM) has played a significant role in Industry 4.0. Along with more and more AM process are applied in manufacturing systems, the issue of energy consumption of AM system attracts attention. It is established as being one of the most important research targets that the AM energy consumption behaviour is well defined, and more efficient AM system usage methods are discovered. However, the AM energy consumption is related to many processing attributes depending on different working principles of AM system. It is necessary to analyse this issue more comprehensively with the multi-sourced data from not only the AM processing but also the working environment, the material condition, and the product design. Internet of Things (IoT) technology is one of the best methods to collect and integrate this data from various data sources and then to reach the research target.

This paper proposes a framework predicting the AM system energy consumption based on multi-sourced data collected from the target system, such as production process data, parameter setting data, material data, and product design data using IoT technology. This framework aims to facilitate control system, production operations and product designs by exploiting energy consumption information extracted from multiple sourced data. In the framework, data mining techniques are applied to build energy consumption prediction modelling based on the collecting multi-sourced data. Finally, a case study is presented to show how the proposed framework is applied. In the case study, multi-sourced data is collected from a selective laser sintering (SLS) process. The findings of this research indicate the benefits of incorporating IoT, and various data mining techniques, including machine learning (ML), and deep learning (DL) to build an optimised AM energy consumption prediction model.

Poster Presentations

AI integrated IoT systems for SAW droplet control and diagnosis

Jin Nanlin

Northumbria University

This work seeks to examine the area of Circular Economy, providing an overview of the development of data-driven circular approaches in manufacturing, particularly in the context of Industry 4.0, from the point of view of Reuse, Remanufacturing, Redistribution and Recycle. Design/methodology/approach –This work is based on a comprehensive review of literature covering over 51 research papers. These papers are analysed using pie charts and bar charts to understand current trends in Circular Economy and related research, and future research directions in the field.

Findings show that research on Circular Economy has been steadily and gradually growing with 2014 and 2015 having the most papers on the subject with 43% of the papers from engineering-related research. ‘Reuse’ is found to be the predominant strategy among surveyed papers. Research which links digital technologies to circular strategies and their application within Industry 4.0 is still a very new area of research and, as such, is an area for further studies.

Papers on Circular Economy and Circular Economy Approaches exists, however, there are no papers that offer an overview of the development of circular approaches within manufacturing. The contribution of this paper is to provide a summary of current trends in circular economy research in manufacturing, within the context of Industry 4.0. A review of this development is provided in the form of illustrative charts and graphs that identifies these trends.

Poster Presentations

Smart Design for Digital Manufacturing in a Connected Marine Industry Value Chain

Joo Hock Ang[1], Cindy Goh[1], Ciel Thaddeus Choo[1], Vijay Prabhakarrao Jirafe[2] and Yun Li[3]

[1]University of Glasgow, [2]Sembcorp Marine Ltd, [3]University of Strathclyde

Digitalisation of ship design, construction and operation are gaining increasing attention in the marine industry as ships become eco-friendlier and smarter. With the advent of industry 4.0, manufacturing is now moving towards more intelligent systems that are highly connected. In the context of shipping, vessels are also becoming smarter with more automated systems and progressively moving towards fully autonomous vessels. In comparison to developments in digital manufacturing and advance vessels, the advances in the area of smart design are lacking. In particular, how can we connect up the entire manufacturing value chain which includes upstream design and downstream ship operation process, considering the product lifecycle?

One promising solution is a network that connects smart manufacturing to smart product and smart design in a close loop process framework. By linking smart design, digital manufacturing and smart operations into a unified digital model, important information can be shared seamlessly across the entire product lifecycle of a ship, achieving a fully connected through-life smart shipping network. Under this through-life smart shipping framework as proposed in [1], smart design will be interconnected with smart manufacturing and smart operations for product through-life consideration. By closing the loop between smart ship and smart design, useful through-life data such as the vessel's operating environment and actual performances can be collected, analysed and feedback into smart design process to improve the design performance of future vessels. One example of smart design is the Hybrid Evolutionary Algorithm and Morphing Approach (HEAM), as introduced by [2] for hull form design and optimisation. Here, we utilise existing hull form data to automatically search and produce optimal design with minimal user intervention. This is achieved by combining the advantages of evolutionary algorithm- ability to search for best global solution- and that of morphing- ability to generate smooth intermittent shapes from the combination of two or more hull form designs.

This poster i) provides an overview of smart design and its relation to digital manufacturing and advance vessels, ii) presents the through-life shipping framework that connects smart design with digital manufacturing and smart operations considering product lifecycle, and iii) introduces a hybrid evolutionary and morphing approach, which can be applied as smart design automation of ship's hull form. Through computational intelligence, we envision smart design can be integrated with digital manufacturing and advance product to achieve the vision of fully connected cyber-physical chain in an industry 4.0 environment.

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[2] Ang, J.H., Goh, C., Jirafe, V.P. & Li, Y. 2017. Efficient hull form design optimisation using hybrid evolutionary algorithm and morphing approach; Conference on Computer Applications and Information Technology in the Maritime Industries, 3-4 October 2017, Singapore.

Poster Presentations

Data Driven Optimisation of Spatial Dynamic Sampling using FSCA

Sean McLoone and Federico Zocco

Queen's University Belfast

Semiconductor products are key elements of every modern device. The semiconductor manufacturing process typically consists of silicon wafers undergoing hundreds of different steps over several weeks to build up the desired complex nanoscale structures. Examples of such steps are chemical vapour deposition (CVD) of thin films on the wafer surface and plasma etching of trenches in the exposed wafer surface following a lithography step. Metrology is essential to monitor the performance of these processes over the entire manufacturing process to ensure that both spatial variation (intra-wafer) and temporal variations (inter-wafer) do not exceed the demanding tolerances required for modern semiconductor devices. However, metrology is a high cost, time consuming, and non-value added operation, hence, due to commercial pressures, standard practice is to keep metrology to a minimum by adopting both spatial and temporal sampling protocols. Here we consider the problem of optimising spatial dynamic sampling plans such that the number of locations measured on each wafer is minimised while retaining the capacity to: (1) generate an accurate reconstruction of the wafer profile, and; (2) to detect previously unseen process behaviour in a finite time horizon.

The solution we have developed [1],[2] is data driven, and involves the analysis of historical metrology data using Forward Selection Component Analysis (FSCA) [3], a greedy search based unsupervised variable selection technique. Using FSCA, the subset of candidate metrology sites that yields the best reconstruction of wafer profiles is determined. The remaining candidate sites are clustered around the FSCA selected sites based on similarity, yielding FSCA clusters. Dynamic sampling plans are then generated by selecting a different candidate site from each of the FSCA clusters at each process iteration.

Results for both simulated and industrial metrology case studies confirm the efficacy of the proposed FSCA based dynamic sampling methodology, with substantial reductions in the number of measurement sites that need to be measured possible for processes that exhibit significant spatial correlation in inter-wafer variability. In particular, analysis of a metrology dataset from a CVD process used in the manufacture of hard disk drives shows that measurements per wafer could be reduced from 50 to 7 while maintaining wafer profile reconstruction accuracy levels of greater than 99%.

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Poster Presentations

Centre for Digital Built Britain (CDBB) Digital Twin

Ajith Parlikad, Duncan McFarlane, Qiuchen Lu, Gishan Don Ranasinghe, Zhenglin Liang, James Heaton, Askar Aryntay and Simon Sennitt

University of Cambridge

The Centre for Digital Built Britain (CDBB) at the University of Cambridge focuses on the ongoing transformation of the built environment through the digital tools, standards and processes that are collectively known as Building Information Modelling (BIM). One of the key activities at CDBB is the development of a dynamic digital twin of the Institute for Manufacturing (IfM) and the West Cambridge Site, University of Cambridge.

A Digital twin refers to a digital replica of physical assets, processes and systems. Digital twins integrate artificial intelligence, machine learning and data analytics to create living digital simulation models that update and change as their physical counterparts' change. A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position. In addition, it can predict and represent the future condition of the physical counterpart. The current activity of the digital twin project in Cambridge is currently being carried out in partnership with Bentley Systems, RedBite, Topcon and GeoSLAM.

In order to demonstrate the impact on facilities management, wider productivity and well-being, this research project aims at developing a dynamic digital twin with multi-layered information models to integrate heterogeneous data sources, support intelligent data query, provide smarter decision-making processes in Operation & Maintenance (O&M) management and further bridge the gap between human relationships with buildings/regions via a more intelligent, visual and sustainable channels. With the basis of the dynamic digital twin supported by an as-is IFC Building Information Model (BIM), facility management systems (e.g., Trend building management system, Planet asset registry and Itemit asset tagging platform) and Internet of Things (IoT), intelligent O&M management will be executed efficiently, and daily events can be automatically recorded, conveniently verified and intelligently controlled in future study. The development is currently structured along three interconnected layers: BIM modelling, asset information management and IoT-based wireless sensor networks and actuators. The long-term goals of this digital twin project are to:

1). Demonstrate the impact of digital modelling and analysis of infrastructure performance and use on organisational productivity.
2). Provide the foundation for integrating city-scale data to
optimise city services such as power, waste, transport and understand the impact on wider social and economic outcomes.
3). Establish a 'research capability platform' for researchers to understand and address the major challenges in implementing digital technologies at scale.
4). Foster a research community interested in developing novel applications to improve the management and use of infrastructure.

Poster Presentations

Feasibility study: Pathway to autonomy for an SME factory

Hongjie Ma, David Brown and Edward Smart
University of Portsmouth

The application of autonomy in manufacturing presents the opportunity to increase productivity, reliability, add value in a competitive arena and compensate for an ageing skilled workforce. It should be emphasised that the higher flexibility often means higher risks to reliability. Autonomy makes it a fully man-labour free factory, but it could lead to the loss of traditional advantages, such as the system failures and risks identified based on the human senses and experience of workers.

In response to these challenges, many individual Advanced Abnormal Perception(AAP) systems have been developed to control the quality of the production or ensure reliable operation of the system. The shortcomings of these AAP technologies are that their versatility is not enough. This study will seek to develop a general-purpose AAP algorithm for cutting down the cost of the maintenance and improving the efficiency of the production process of some flexible manufacturing SME factories. This ideal general AAP technology should be application independent, which means that it should be as follows:

[1]A self-learning system with the abilities of on-site unsupervised learning or semi-supervised learning. This means that the anomalies of different objects (mechanical system, hydraulic system, electrical system etc.) in the autonomous manufacturing with different physical signals (vibration, pressure, current, temperature, etc.) can be perceived with no difference.

[2]A measure independent system, which doesn’t interfere with a production line. This can reduce the deployment cost of sensing technology, especially for legacy systems. This means that general AAP technology should take non-invasive sensors as inputs, such as camera, vibration sensor and inductive current sensor etc.

Poster Presentations

Predicting Faults in Manufacturing Production Environments with Limited Component Specification Data

Edward Smart, Hongjie Ma, Ann Swift and David Brown
University of Portsmouth

This research shows how condition monitoring can be effectively used to analyse milk filling machines within a just-in-time production environment. This is challenging as these machines run 22 hours a day, 7 days a week, where the focus is on achieving strict production targets regardless of machine condition. Fault detection is difficult as maintenance logs can be incomplete, operating conditions are often unknown and component specifications are missing or incorrect.

The novelty is that the proposed approach requires no knowledge of the dairy filler components to accurately quantify filler health using one class support vector machines (SVM) on individual components as well as overall. It does this by using a combination of time and frequency features extracted from vibration data. Furthermore, training of the SVM only requires artificial data. It was found that faults on multiple components could be detected, which, if left, could have led to catastrophic failure and cost the dairy upwards of 400,000 GBP per day.

Significantly, a non-invasive condition monitoring system for a low-tech 'just-in-time' industry has been developed that not only avoids the need for frequency analysis but can accurately detect and quantify the severity of multiple faults.

Poster Presentations

A Context-Aware Internet of Things Framework for Remote Monitoring Services

Ali Al-Shdifat, Christos Emmanouilidis and Andrew Starr

Cranfield University

With global competition and technological progress, there have been growing demands by industry for more efficiency in monitoring the health status of manufacturing equipment. Internet of Things – driven and cloud-supported monitoring services are nonetheless faced with some of the typical challenges of big data. Further research is required to adequately manage and exploit such data to deliver high added value monitored services. Among the key concepts in handling the relevant big data challenges is that of context information management. This poster proposes a context-aware framework for the integration of internet of things and cloud computing for remote monitoring services.

Poster Presentations

Digital Transformation Strategy Framework for Gait Analysis

Arif Reza Anwary[1], Hongnian Yu[1] and Michael Vassallo[2]

[1]Bournemouth University, [2]Royal Bournemouth Hospital

Gait analysis is an important objective in different areas such as medical and rehabilitation clinics to diagnose and treat patients with various gait disorders. There are other potential uses including sports, to monitor an athlete's performance and research laboratories for biometric gait analysis. Currently such analyses depend on access to expensive complex equipment often based in gait laboratories. Gait analysis is therefore not widely available due to various reasons including scarcity of expensive equipment, need to attend a laboratory, complicated time consuming procedures needing technical or clinical staff and overall expense.

Improving opportunities for gait analysis to increase accessibility requires a major transformation strategy framework of gait analysis that includes the development and use of new and affordable technologies for diagnosis and monitoring of gait using digital technology. We have developed an automatic wearable multi-sensor Inertial Measurement Unit based system for gait analysis This will open opportunities for structural change in the delivery of healthcare. Therapists will be able to make complex assessments and patients will be able to monitor gait in their own home removing the need to attend hospitals or clinics. By using remote monitoring technology therapists, general practitioners and patients can use the same platform to monitor and make treatment decisions together. Therefore, we design a digital transformation strategy framework (DTSF) for gait analysis based on the development and use of new technology, changes to value creation, structural change and affordability.

Poster Presentations

Digitalization of food manufacturing

Bogdan Dorneanu, Evgenia Mechleri, Sai Gu and Harvey Arellano-Garcia

University of Surrey

For thousands of years food preparation was an unpretentious task conducted based on empirical artisanal practices and meant only to ensure survival. As more scientific fundamental knowledge was elaborated, new technologies such as commercial sterilization, the introduction of the evaporator, or the freezing made possible the shift to generic production lines with benefits of preservation, low cost and high throughput of continuous manufacturing processes. However, in a food value chain driven by producers, ample availability, convenience, and low-priced foods are no longer enough for the consumers as there is increasing evidence of a link between diseases and diets. Unlike other manufacturing sectors such as chemical, aerospace or automotive engineering, with decades of modelling and virtualisation activities, the food manufacturing is still to a large extent based on empirical approaches. The shift from empirical to physics-based modelling offers the challenge for a better understanding of the food products and processes, the consumer's behaviour, needs and expectations, for a personalisation of food, and the move from the mass production-type of approach to target consumer groups with unique requirements.

The scientific progress in areas such as biological sciences, medicine, nanotechnology, new sensor technology, proliferation of the Internet of Things (IoT), connectivity and big data-analytics, enables virtualization of food manufacturing processes to benefit from enhanced modelling and computational power. Knowing the detailed way in which the product comes into being and the way it transforms from the moment it leaves the factory and until is being consumed results in the creation of analytical tools for reformulating and restructuring products and their manufacturing, to respond to the consumer needs, while maintaining their sensorial and functional quality. This work will present key challenges faced in the digitalization of food products and processes, and of physiological consequences products have on the consumer. Moreover, it will propose a conceptual framework for an integrated solution of a digital ecosystem product – process – consumer that can be used to virtually simulate manufacturing of new products, predict crucial maintenance needs and adapt consumer's requirements.

Poster Presentations

Intelligent Personalised Powertrain Health Care (inPowerCare)

Esmaeil Habib Zadeh, Thomas Byrne, Felician Campean, Aleksandr Doikin, Natasha Micic, Daniel Neagu, Morteza Soleimani and Denis Torgunov

University of Bradford

The state of the art developments in “Total Care” systems is illustrated by the aerospace “Integrated Vehicle Health Management” (IVHM) strategy for prognostics and health management, which enables continuous monitoring and real time assessment of vehicle functional health; predicts remaining useful life of components and systems; and uses the insights to improve operational decisions such as maintenance planning. To date, significant progress in this direction has been made in many industrial domains including automotive, all facilitated to a great extent by Big Data tools and technologies with respect to structure, organisation and analysis.

Data in the Digital Age is indeed the new fuel that powers Machine Learning (ML) tools and algorithms to harness Artificial Intelligence (AI) and allow for development of enhanced diagnostics and prognostics health systems that are capable of monitoring and proactively managing the products functional health throughout their lifetime. Thankfully, recent developments are dominated by the proliferation of sensors, which are an integral part of and connected through the Internet of Things (IoT), the implication being that the availability of large engineering data sources is ever increasing.

Therefore inspired by the aerospace IVHM strategy, although well-aware of distinctions, we develop a Total Care framework that leverages a great variety of heterogeneous data sets available and translates them into actionable insights on the basis of individual cars. More specifically, the framework integrates advanced data science and knowledge discovery methodologies with structured engineering model based analysis and reasoning to enable multi-scale decision making processes for diagnostics and prognostics.

Such a synergistic integration of engineering and data science expertise offered by the Bradford team has provided the opportunity to progress towards the unique vision of a digital health solution for the vehicle, building on the current developments to integrate large data sets with Big Data technologies within a total healthcare paradigm.

Poster Presentations

Feasibility study: A digital garment simulation model links consumer preference with objective fabric properties

Ningtao Mao[1], He Wang[1], Zhiqiang Zhang[1] and Laura Finnigan[2]

[1]University of Leeds, [2]Burberry

The objective of this project is to develop a digital garment simulation model to connect consumer preference of garment in both visual aesthetics and sensory feel with objective fabric properties.

Virtual garment simulation is a rapidly evolving technology, which has the potential to shorten the fashion design process and be used to visualise clothing for online shopping. However, existing computer simulation of garments provide only pale imitations of the real garments, missing details such as how a specific fabric drapes and feels. In this project, fabric properties characterised using a newly developed instrument, LUFHES, will be incorporated into the simulation algorithm to connect consumer's sensory preferences for a garment's drape and feel with objective fabric properties. This will enable garment designers to acquire valuable feedback to achieve a desirable customised fashion product or a desirable mass market garment.

Poster Presentations

Positioning Multidisciplinary System Objects Toward Multidisciplinary Residual Life Cycle Artefacts

Thomas Byrne, Felician Campean, Aleksandr Doikin, Esmaeil Habib Zadeh, Natasha Micic, Daniel Neagu, Morteza Soleimani and Denis Torgunov

University of Bradford

First, we asked machines to ‘do’, then ‘think’, now we want them to ‘learn’. Data is the new fuel that powers machine learning and decision making, converging from multidisciplinary systems (e.g. mechanical, electrical, electronic, information, and communication systems) and a heterogeneous range of data and information sources. Physical, Information and Communication (PIC) systems are divergent disciplines, disparate in conceptual design and functional and non-functional requirements. In keeping with customer expectations, our objective is to converge these disciplines under a common artefact that is accessible across the whole product life cycle.

At the University of Bradford’s Automotive Research Centre, we address the multidisciplinary problem at the constituent level of design, using ontological methodologies to build a conceptual artefact that is compatible with all PIC systems at all stages of collaboration - most significantly at the operational stage in cyber-physical systems. This methodology is based on how we structure the world, rather than the way the world is structured. Through objects and associated phenomena, we perceive the world in our mind, so that the conclusion is, that Newtonian science is dealing with subjective structures of our thinking.

All causality is time space and event based, around relationships between the fundamental states of matter. Through axiomatic categorisation, information sources (e.g. durability test data, material and manufacturing process data, maintenance / warranty data, dimensional metrology data – in test, manufacturing and after use) and online sources (e.g. sensor data recorded by ECU or available as data over the air (DOTA), electronic systems diagnostics), converge into a homogenous system of physical components associated through their information system counterparts; inherit associations with reciprocal components, thus other data, through their Physical System State Parameters (PSSP).

Axiomatic categorisation interpolates data objects with low-level logic that serves as a starting point for other, more complex, logical statements in higher-level applications. For example, axioms in the Category of Relation associate data objects with DOTA, at which point, functional system state parameters mapped to the PSSP determine interdependencies amongst components, whereby the reciprocal causality of physical components, in respect of fault detection events, is the coexistence of the determinations of one component with that of another. In other words, the causality of fault detection events, when posited, is always followed by something else (other events in other components), insofar as a ‘particular event’ must be concurrent with or antecedent to a ‘particular cause’ and substantiated through the reciprocity of action and reaction between physical components and their associated phenomena. Using this methodology, disparate engineering disciplines have a unanimous set of accords through axiomatic categorisation that synchronise a cross-disciplinary comprehension of object artefacts and associated phenomena and allows us to refer to all possible relationships between data-objects and events in real time and learn with autonomous authority.

Poster Presentations

Flexible Digital Manufacturing for Freeform Manufacturing of Thermoplastic Composites

Pablo Jaramillo and Patrick JP Fairclough

University of Sheffield

Fibre Reinforced Composites (FRCs) are considered as the materials of the future mainly because of the possibility to produce stronger and lighter structures which is associated with an improved fuel consumption in powered applications. However, there is little in terms of traceability and limited feedback to improve manufacture which limits composite's spread. In addition, even though several techniques might be suitable for small batches, individual customization is penalized due to the production of new and sometimes expensive moulds.

This project aims to change this implementing a machine learning flexible digital manufacturing approach to create mould free composites for low cost, high-quality, and individual customization. Based on successful results of a simplified incremental sheet forming (ISF) tests, a prototype machine is being built and adapted to produce mould free and data rich fabrication of composites. Indentation forming is a simpler variant of ISF. The results of indentation forming procedures over consolidated laminates made of Self-Reinforced Polypropylene (SRPP) have shown that geometries like cone were readily achieved without the necessity of a mould. It was found that affect the formability of the material is affected by several process parameters such as forming temperature, boundary conditions, and indentation pattern. It is envisioned that mould free composite manufacture could revolutionize the design, flexibility and concept of the composites industry, if the concept proves to be feasible.

Poster Presentations

What will happen when the high-performance computing centre is connected to the production line in real time?

Ann Swift, Edward Smart, Shuai Hongjie and David Brown

University of Portsmouth

For the fault detection or fault prediction of a production line, we always need to find a balance between efficiency and accuracy. Complex models usually lead to higher precision but at the same time reduce detection (or prediction) efficiency especially for complex large-scale production lines. High-performance computer (HPC) provides more freedom for the diagnostic or prediction model while ensuring the efficiency.

In this study, we established the connection between the production lines from a large milk manufacturer and the HPC from EPCC. With the help of the powerful computing capabilities, we achieved near real-time diagnosis, prediction, and visualization of multiple complex systems.

Poster Presentations

Computing craft: development of a robotically-supported 3D printing system for cob structures

Wassim Jabi[1], Aikaterini Chatzivasileiadi[1], Mohamed Gomaa[2], Alejandro Veliz[3] and Nicholas Wardhana[1]

[1]Cardiff University, [2]University of Adelaide, [3]University of Plymouth

The “Computing Craft” project focuses on exploring fabrication procedures and methodologies for robotically supported 3D printing utilising cob and other clay-based sustainable building materials. It emerges from an ongoing line of collaboration between Plymouth University and Cardiff University. The methodology being followed is that of a prototype development process within the framework of a feasibility studies call funded by Connected Everything through the University of Nottingham and EPSRC.

The project is the first to adopt a design-driven cross-disciplinary approach to translating the craft-based process of cob construction into a digitally-informed and automated process. It, therefore, expects to not only reveal technological and design opportunities for 3D printed cob structures, but more broadly to engage with vernacular practice and situated knowledge through digital means. As a result, the narrative throughout this project establishes intelligent material cultures and practices as a rich source of digital and creative innovation.

This project expects to contribute to the discipline by providing a framework engaging with digital practice to bridge the knowledge gap - both epistemologically and methodologically - between professional/academic and vernacular modes of knowledge production, dissemination and representation. This presentation specifically focuses on early stages of the project, more closely related to material studies, potential robotic printing configurations and early prototype development informing the determination of material qualities (e.g. mix ratios), extrusion mechanisms through systems integration, early material tests and prototypes, and early indications of upcoming working packages and emergent lines of inquiry.

Poster Presentations

The Future Agricultural Worker - A Micro Air Vehicle Solution For Autonomous Pollination

Leo Chen[1], Yun Li[2] and Hongnian Yu[3]

[1]Dongguan University of Technology , [2]University of Strathclyde, 3Bournemouth University

Food security has been one of the hottest topics of all nations, which is of concern to the world for a variety of reasons, including its social-economic-environmental coupled impacts on the well-being of human being, social life, the national and international agricultural policies, etc. As estimated one-third of all food consumed by humans is the result of animal pollination.

This paper proposes a conceptual technical roadmap of autonomous pollination for future farming using robotic micro air vehicle pollinators (MPrs) associated with artificial intelligence and Human's expertise, which can perform an MPr pollinator roles in smart agricultural industry. This research provides an emerging solution to the food supply reduction caused by the population shrinking of natural pollinators, which strongly influence ecological relationships, ecosystem conservation and stability, genetic variation in the crop plant community, floral diversity, specialisation and evolution. This work identifies scientific and technological advances that are expected to translate, within the proposed regulatory frameworks, into the pervasive use of MPrs for agricultural applications and beyond.

Poster Presentations

Digital manufacturing for Welding and jointing technologies

Darren Williams

TWI Ltd

TWI Welding Systems Integration

TWI is one of the world's foremost independent research and technology organisations, with expertise in materials joining and engineering processes as applied in industry. TWI specialises in innovation, knowledge transfer and insolving problems across all aspects of manufacturing, fabrication and whole-life integrity management.

The aim of the Welding Systems Integration(WSI) team is to provide the next generation of Smart Autonomous Digital Welding Systems based upon TWI's world-class process knowledge, developed within the context of the latest digital manufacturing philosophies underpinned by Industry 4.0.

Poster Presentations

Selecting Additive Manufacturing or Dedicated Manufacturing: A Strategic Technology Choice

Duncan McFarlane and Mudassar Ahmed

University of Cambridge

The unexpected events causing disruptions in a production environment are of three types: “upstream” disruptions in the form of delayed or defective supply of parts to manufacturers, “internal” disruptions resulting due to a machine breakdown or lack of resource availability, or “downstream” disruptions which come directly from customers in the form of a customisation request, changes in lead time, or a rush order. This downstream disruption – from the customer end – is facing a significant increase owing to the emerging shift from identical mass-production paradigm towards more customised solutions ideally with shorter lead times. This is understandably posing challenges to existing production systems. For these reasons, Additive Manufacturing (AM) — more commonly known as 3D printing — is seeing a surge in its use from just prototyping to finished goods. AM’s ability to manufacture on- demand in batches as small as one with exceptionally low set-up time and switching costs makes this so-called “factory-in-the-box” an attractive alternate to potentially help address the above customer disruptions.

This poster examines the potential for AM to address demand uncertainty. It highlights the use of game theory to study the impact of competition on a firm’s choice of technology (product dedicated or product flexible e.g. AM) and capacity investment decision. More specifically, the poster presents a model between two competing firms in two markets under demand uncertainty to help them make three decisions: choice of technology (technology game), capacity investment (capacity game) and production quantities (production game). The poster then shows the best response function for each firm in the technology game and compare how a competing firms respond to a given flexibility premium. Initial results of these analyses will be presented in the poster. The research is expected to offer a decision support tool for the adoption and effective deployment of AM in a production environment.

Poster Presentations

Anomaly Detection via One Class Classification Methods for Industrial Diesel Engines

David Brown, Edward Smart, Hongjie Ma and Ann Swift

University of Portsmouth

Although extensive research has been undertaken to detect faults in industrial diesel engines, significant challenges remain such as the need for non-invasive monitoring methods and the need to obtain rare and expensive datasets of multiple faults from which machine learning algorithms can be trained upon. This research presents a method that uses non-invasive engine monitoring methods (vibration sensors) and doesn't require training on faulty data. Significantly, the one class classification algorithms used were tested on a very large number (12) of actual diesel engine faults chosen by engine experts, which is rare in this field.

The results show that by learning on only easily obtainable healthy data samples, all of these faults, including big end bearing wear and 'top end' cylinder leakage, can be detected with very minimal false positives (best balanced error rate of 0.15%) regardless of engine load. These results were achieved on a small 3-cylinder test engine.

Significantly it highlights how the 'healthiness' of an engine can be assessed and monitored over time, whereby any changes in this health score can be noted and appropriate action taken during scheduled maintenance periods before a serious fault develops. .

Poster Presentations

Versatile Intelligent Portable Platforms (VIPRO) for Developing the IT Industry 4.0 Concept

Luigi Vladareanu[1], Hongnian Yu[2] and Victor Vladareanu[3]

[1]Romanian Academy, [2]Bournemouth University

Versatile Intelligent Portable (VIPRO) Platform concept develops the versatile, intelligent and portable control interfaces in the virtual reality environment, validated in real time on a classical own mechatronic control system and/or an own physical mechatronic system, with the aim of improving system performances for motion, navigation and orientation, having as main applications control systems for nano - micro - macro -manipulators, mechatronic and humanoid systems.

VIPRO concept enables developing the IT Industry 4.0 concept through the design, testing and experimentation of new intelligent control interfaces on a classical mechatronic control system (SCMC) in the presence of the physical mechatronic system (SMF), with own control system and mechanics structure, or in the absence thereof, without the need to modify its hardware structure, and, from optimal decisions and information fusion between the intelligent control interfaces, resulting in a high degree of versatility and portability to a global communications network.

An original virtual projection method is applied to smart firefighting robots, through representation of the intelligent mobile robots in a 3D virtual environment using a strong robotic simulator, an open architecture system and adaptive networks over the classical control system of the robot.

The system is designed for motion and navigation on rough terrain and uncertain environments, allowing rescue activities in crisis situations or natural disasters areas in which human life is in danger.

Poster Presentations

Smart Robots for Firefighting

Shuang Cang, Hongnian Yu[2], Luigi Vladareanu[3], Feng Gao[4], Zengguang Hou[5] and Yongshen Zhao[6]

[1]Northumbria University, [2]Bournemouth University, [3]Romanian Academy, [4]Shanghai Jiao Ton University, [5]Chinese Academy of Science, [6]Yanshan University

Over the years, changes in modern infrastructure have introduced new challenges to fire-fighting practices. Training and research programs have been developed to manage these challenges but there are still significant losses from fires each year. In 2013 alone, the fire departments in the USA responded to over 1.2 million fires which resulted in about 3,420 civilian fatalities, 15,925 injuries and property losses of about $12.4 billion dollars. In the UK, 192,600 fires responses, approximately 350 civilian fatalities, 10,300 injuries. The firefighting and rescue functions of the existing equipment and apparatus and their dexterity are limited, particularly in the harsh firefighting environments.

This poster reports the recent EU funded SMOOTH (Smart Robots for Firefighting) project which aims to propose a novel robot-assisted decision making system in smart firefighting to perform searching and rescuing practice in the fire ground, and to facilitate the decision makings with higher efficiency.

Poster Presentations

Integrating Cognitions of Human Operators in Digital Robot Design (ICHORD)

Sarah Fletcher

Cranfield University

Advances in sensing and monitoring technology mean that it is now possible for people to work safely and collaboratively with large high-payload industrial robots, on shared tasks in shared spaces, whereas previously these robots had to be physically segregated by fencing. This means we now face an impending growth of human-robot collaboration in manufacturing which will inevitably place new demands on workers. Working with a large robot, previously deemed too dangerous for close proximity, is likely to invoke new cognitive-behavioural reactions which may affect system performance. However, although it is well known that new technologies and processes often fail due to a lack of human factors in design, current manufacturing system design techniques still do not address such human reactions. Digital human modelling (DHM) tools only offer a limited degree of physical / ergonomic analysis but no capability for analysing psychological data / impacts.

The aim of the ICHORD project is to test the proposition that it is now possible to integrate a cognitive-behavioural rule into DHM software to improve the efficacy of manufacturing system design. To test this feasibility a real manual assembly process will be digitally remodelled into a new collaborative human-robot system with the incorporation of a simple cognitive-behavioural rule linking levels of human trust to a robot's speed / motion (developed in previous work). The redesigned system will then be physically constructed in a laboratory setting and performance of the new system, including human responses, will be compared to that of the original process to evaluate whether the trust-speed/motion rule has been accurately transferred. The degree to which the original and new task performance data correlate will indicate the degree to which the integration of the rule in DHM has been effective. This is the first known attempt at integrating cognitive behavioural data in DHM and, if successful, will pave the way for applications in other contexts.

Poster Presentations

Energy- and Labour-Aware Production Scheduling Method for Industrial Demand Response Using Adaptive Multi-objective Memetic Algorithm

Ying Liu

University of Glasgow

Price-based demand response stimulates factories to adapt their power consumption patterns to time sensitive electricity prices, so that a rise in energy cost is prevented without affecting production on the shop floor. This paper introduces a multi-objective optimisation (MOO) model that jointly schedules job processing, machine idle modes, and human workers under real-time electricity pricing. Beyond existing models, labour is considered due to a common trade-off between energy cost and labour cost.

An adaptive multi-objective memetic algorithm (AMOMA) is proposed to fast converge toward the Pareto front without loss in diversity. It leverages feedback of cross-dominance and stagnation in a search and aprioritised grouping strategy. In this way, adaptive balance remains between exploration of the nondominated sorting genetic algorithm II and exploitation of two mutually complementary local search operators. A case study of an extrusion blow moulding process in a plastic bottle manufacturer and benchmarks demonstrate the MOO effectiveness and efficiency of AMOMA. The impacts of production-prohibited periods and relative portion of energy and labour costs on MOO are further analysed, respectively. The generalisation of this method was further demonstrated in a multi-machine experiment. The common trade-off relations between the energy and labour costs as well as between the makespan and the sum of the two cost parts were quantitatively revealed.