Impact Objectives

- Supplement human ingenuity in science, thereby opening up new areas of thinking and hopefully fuel new breakthroughs and discoveries
- Change the face of scientific research and revolutionise how research and development is undertaken
- Continue to promote the benefits of collaboration

A marriage of technological innovation and human ingenuity

__Professor Feng Dong__ is the coordinator of an exciting research project that marries scientific creativity and innovation to supplement human ingenuity in science. Below, he describes his background, the inspirations behind this unique undertaking, and how collaboration plays a vital role in the success of the project

Can you begin by introducing yourself, your key research interests and passions in life and work?

I am a Professor of Visual Computing at the University of Bedfordshire, UK. I joined the University in September 2007, having previously worked at Brunel University, UK. I was awarded my PhD from Zhejiang University in China, where I became a member of the academic staff at the State Key Lab of CAD and Computer Graphics, the leading computer graphics lab in China. I have also worked as a lecturer at Lancaster University in the UK.

I have many research interests, including computer graphics, medical visualisation and image processing. Much of my recent work has developed into new areas, including visual analytics, pattern recognition, image-based rendering and figure animation. I am currently leading a research team that has been involved in large-scale research grants in healthcare and creative learning from national and European funding bodies. My team is working on big data management and storage on a cloud environment; mining and visualisation of massive data; and text mining and semantics of web information. I am coordinating two European projects, and am the Principal Investigator of external research funding in excess of 2 million euros.

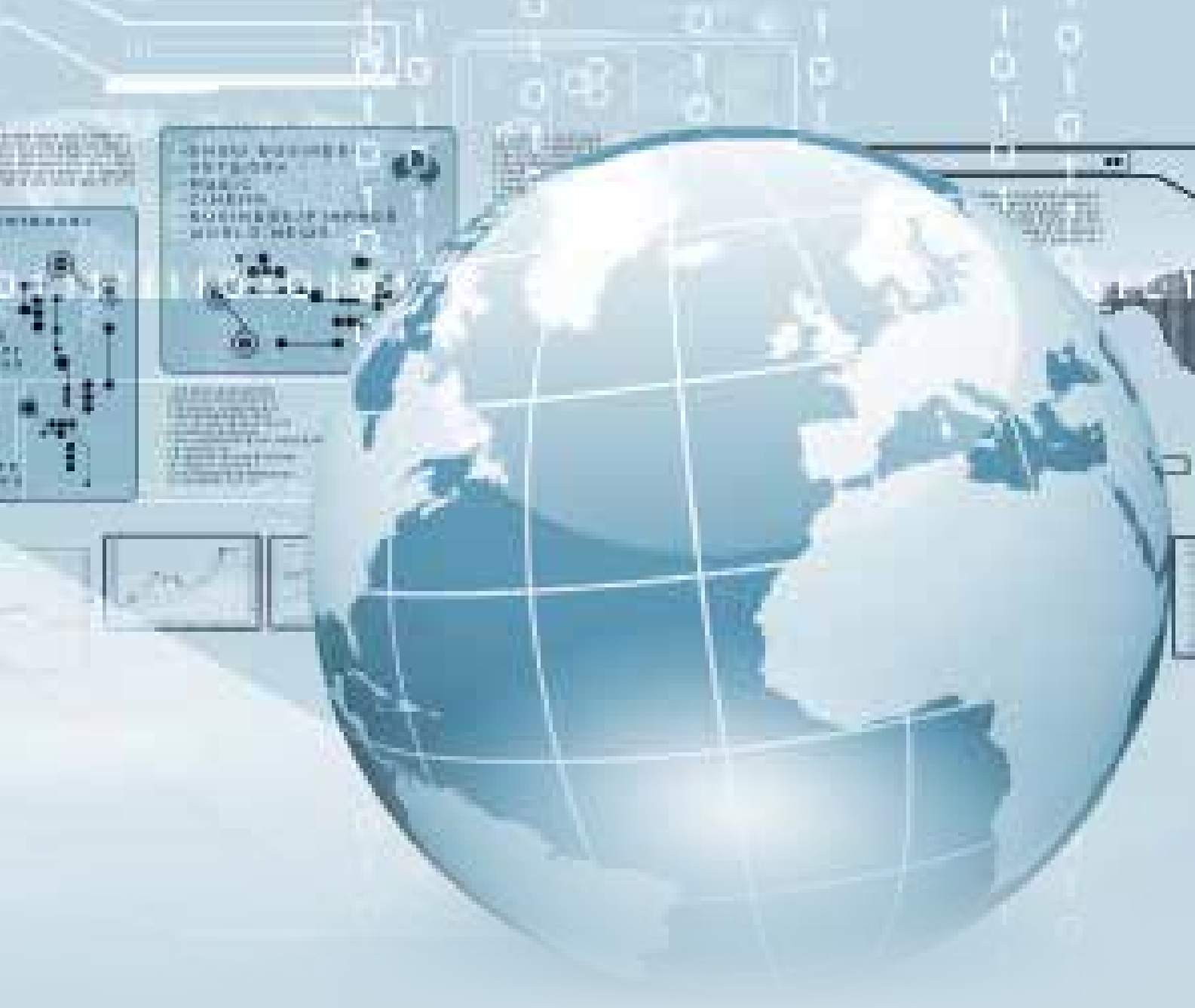
The Dr Inventor project is built on the idea that technologies have the potential to supplement human ingenuity in science. Can you elaborate on this?

While human creative thinking is a far more complicated process than can be replicated by machines, our capacity is often severely limited by human nature. A sound knowledge base of an individual requires many years of study to formulate. In addition, people suffer from limited working memory and a lot of thinking barriers, such as selective thinking, perception limitation, biases, problem fixation, etc. Studies have also shown that human thinking is often affected by many unpredictable factors, such as attention spans, environment and health. The vision of Dr Inventor is that we can enhance human creativity by seamlessly integrating modern technologies with human ability.

Collaboration obviously plays an important role in the success of the project. Can you explain in what ways and what each collaborator brings to the table?

Dr Inventor is designed to experiment and understand technology potentials in human creative processes to enhance domain-specific human creative performance. The consortium has been formed by eight partners across five different EU countries, ranging from East to West, which covers all the essential elements of the project, including the scientific, technical, industrial and evaluation aspects. The partners were selected according to the requirements of the project, their expertise and experience, as well as their complementarity. This brings together the diverse elements needed and a critical mass in order to reach the aim and objectives of the project.

To ensure that the developed concept of Dr Inventor is useful and acceptable, Dr O'Donoghue from Maynooth University, Ireland was brought in to play an important role. O'Donoghue has substantial expertise in computational creativity and contributed to the research of theoretical modelling and operational definition of scientific creativity, and leads the technical implementation of the theoretical model, which is supported by the technical partners. O'Donoghue is deeply involved in the development cycle, leading two work packages in the investigation of the theoretical model and the technical implementations of the model. He also contributes significantly to the evaluation by



working closely with the domain experts. In addition, the industry partners directly exploit the work to improve their existing product for market – all these ensure that Dr Inventor will have a foreseeable impact.

What methods are you using throughout the course of your research and what do you hope each will achieve?

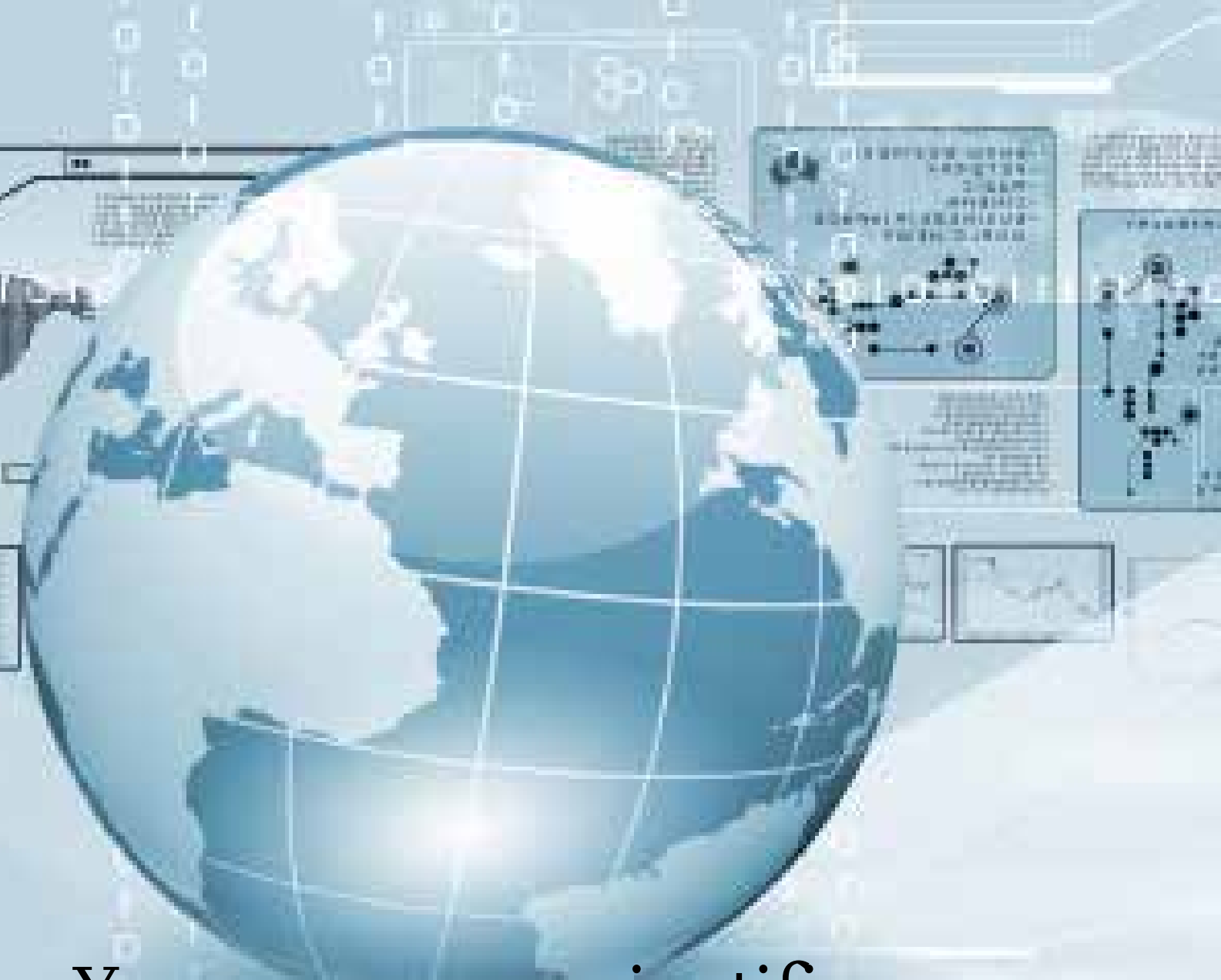
New technologies, especially artificial intelligence, are drastically changing the nature of creative processes. Dr Inventor is built on the vision that technologies have a great potential to enhance scientific creativity. Currently, scientific innovation is still largely reliant on human brains. Modern technologies, such as information extraction, document summarisation, semantic web and visual analytics have great potential for supplementing human ingenuity by overcoming the limitations that people suffer in their efforts towards creativity, such as limited knowledge and inherent thinking barriers. The project commits to generating a web-based system that supports real-world applications for scientific innovations in a specific domain. By doing so, we seek insights of the potential and limitations of the technologies in scientific creative processes under real-world settings, leading to a blueprint of future technologies in computational creativity.

Can you talk about some of the results that you have achieved so far?

We have tried to validate outcomes of the underlying creative model in the core research in computational creativity. All the necessary technology components are integrated into a web-based platform, which we have made available. It targets computer graphics researchers by allowing them to do three specific things. First, they can search for a target paper that was included in Siggraph from 2002 to 2016 (Siggraph is the top computer graphics conference), and find new research ideas to extend the target paper. The target paper should be a research paper related to the research interest of the researcher. In addition to the target paper, the platform can also provide a source paper, which may come from a completely different research topic. The system shows a potential link between the two papers, based on which set of new research ideas can be suggested to extend the work from the target paper.

Second, we have developed a 'try your idea box' – where a researcher can try to add a free text on the system dashboard, one that summarises their research ideas. The system can find a source paper with a suggestion of analogy, based on which suggestions of new research ideas can be provided. Third, researchers are able to search for relevant research papers and topics in the system.

The platform is available to the public at http://drinventor.ccgv.org.uk/Div/login



Your very own scientific research assistant for the future

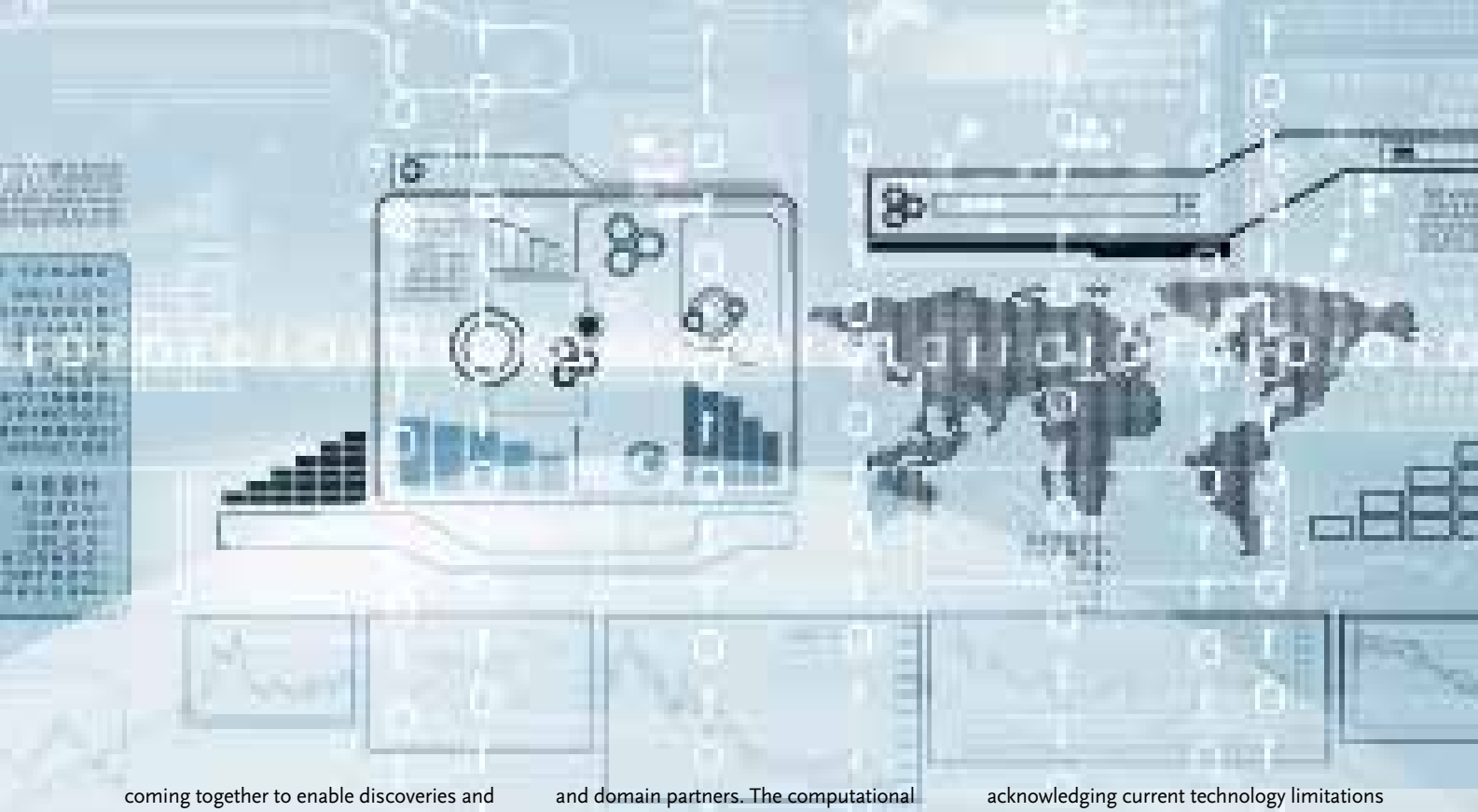
***Dr Inventor** is a unique attempt to understand the potential technology holds for the scientific creative process within current technology limitations. The findings from employing the system could one day lead to novel approaches to research that fuel new discoveries, understanding and inventions*

Ingenuity is often seen as the process of applying original ideas to solve problems that have long evaded solution. While human beings have existed for approximately 200,000 years, it is only relatively recently that the ingenuity that resides in individuals has manifested itself. Indeed, it could be argued that the last 200 years or so have given rise to an incredible amount of discoveries and inventions that shape the world we live in today. Perhaps more astonishing is the notion that human ingenuity is accelerating at an unprecedented rate; one only has to look at everything that has come about over the last two decades to see that the wonders we associate with contemporary life are being developed at a remarkable rate.

A fundamental part of ingenuity is creativity, which can be seen as a way individuals examine a problem with new modes of thoughts to explore new possibilities outside what might be considered traditional approaches. One key example of this can be found in artificial intelligence – in 1997, IBM was proud to narrowly beat Russian chess grandmaster Garry Kasparov with their Deep Blue chess-playing computer, but almost 20 years later, Google used their AlphaGo computer programme to comprehensively defeat 18-time world champion Lee Sedol. It is difficult to overstate the complexity of AlphaGo compared to chess, but in defeating Sedol many programmers around the world considered that the 'holy grail' of artificial intelligence had been attained. However, it is important to realise that without human ingenuity in the first place, AlphaGo (or Deep Blue) would never have been created.

A COMING TOGETHER OF MACHINES AND MINDS

Given this, there is clearly a case to be made for technologies and human ingenuity



coming together to enable discoveries and improve understanding. It is with this in mind that a consortium has come together to inspire creativity in computer graphics research. The project, known as Dr Inventor and coordinated by Professor Feng Dong and Dr Diarmuid P. O'Donoghue, marries scientific creativity and innovation to supplement human ingenuity in science. The premise behind the project is that scientific innovation is currently heavily reliant on human brains, so employing modern technologies, such as information extraction, document summarisation, semantic web and visual analytics have great potential for enabling humans to overcome some of the limitations associated with creativity, such as limited knowledge and inherent thinking barriers.

The project receives funding from the creativity unit at the European Commission's Seventh Framework Programme, and involves eight different partners from five different EU countries, each of which are tasked with specific objectives that complement the others' in reaching the goals of the project. 'The nature of the project suggests that a supportive and interdisciplinary environment is essential. It creates a collaborative working environment, supporting knowledge and data sharing for integrative research across different key areas,' explains Dong. 'All the partners play as a bridge to link the project to a critical aspect, namely, computational creativity, information and communications technology (ICT), domain experts for evaluation and marketing.'

There are computational creativity partners, technical partners, industrial partners, and domain partners. The computational creativity partner has extensive research experience in creativity-related research and cognitive science, especially in the work of analogical reasoning and conceptual blending for scientific innovation in computational creativity. The technical partners consist of ICT experts in information extraction and document summarisation, semantics and visual analytics. The industrial partners are active players in industries relevant to the project; and the domain partner is an expert in computer graphics and animation.

OVERCOMING HUMAN LIMITATIONS TO REALISE TECHNOLOGICAL POTENTIAL

Dr Inventor involves technologies that can enhance human creative performance by overcoming some limitations inherent to human beings and, using computer-based analogical reasoning, can tirelessly explore all potential analogies that are far beyond the reach of human thinking. The system that comprises Dr Inventor acts as a personal research assistant and provides inspiration for scientific creativity by utilising existing research resources. Where an individual would have to trawl through countless pieces of information in order to find something of particular interest, Dr Inventor uses heightened search and computation power to bring researchers extended perspectives. In so doing, it exposes researchers to relevant research concepts and approaches, and offers suggestions of new concepts that have the potential to fuel future scientific discovery.

Importantly, while Dong and his team see Dr Inventor as an attempt to understand the potential of technology within the scientific creativity process, they do so whilst acknowledging current technology limitations – as the technology improves, so too does the potential for the system and, therefore, the potential for new and innovative scientific discoveries. 'While the technologies appear to have great potential, we are fully aware of their limitations, despite their significant progress in recent years,' explains Dong. 'Dr Inventor is designed as an attempt to better understand the potentials of the technologies in scientific creative processes under the current technology restrictions and hence to foresee the future.'

ENABLING FRESH APPROACHES FROM RESEARCHERS

Although still in its infancy, Dr Inventor represents the very first innovation of its kind and has the potential to change the ways in which scientific research is undertaken in the future. By utilising the rich research resource, the system could soon be seen as an essential tool for researchers. The system's capacity for reporting is far beyond that of any individual and can therefore inform researchers of a wide variety of relevant concepts and approaches through machine-empowered searches and visualisation. This enables researchers to approach their topic of interest – and related ideas – from an extremely broad angle, thereby imbuing them with new perspectives that are wholly conducive to re-envisioning their particular problems to bring new solutions to the fore.

In addition, Dr Inventor provides assessment and inspiration through its assessment of the information that is inputted. 'It compares the

> *Dong and his team hope to strike a balance between man and machine – one that takes individual scientific creative processes and marries them with innovative technologies*

novelty of an input into research documents with recognised research approaches and established quality metrics,' explains Dong. 'This leads to potential applications in peer reviews for research papers, grant proposals and patents. It also suggests new research ideas to the users in an autonomous manner.' Fascinatingly, this aspect of the system can be said to replicate human creativity to a certain degree by taking advantage of computing power to generate new concepts with unexpected features.

QUANTIFYING THE CREATIVE RESEARCH OUTPUTS

Given that Dr Inventor functions as a means of bolstering the creative potential of individual researchers, evaluating the creativity outcomes from it is wholly desirable. However, quantifying such outputs constitutes the main challenge to the team. 'The creative performance of Dr Inventor is comprehensively assessed through a well-designed evaluation scheme, which defines evaluation metrics and benchmarks for scientific creativity,' explains Dong. 'From this, we can measure creative performance by means of looking into the Dr Inventor outputs and evaluating the system usability.'

The scientific creativity evaluations within the system include a real-world test-bed, that involves measuring the creative processes of a variety of participants. That Dr Inventor is built to address research problems in the area of computer graphics and animation necessitates the team engaging with academics and PhD students within this field. Through this mechanism, the users in the selected area of research contribute to direct and indirect evaluation frameworks – the challenge is encouraging people to get involved and then provide the necessary information. Alongside this feedback, the team have developed specific metrics to evaluate the effectiveness of the technologies in quantitative terms. 'The challenge here is to develop a general methodology that leads to the generation and representation of these metrics,' explains Dong. 'The underlying research must be domain independent and, given that there is little previous research effort in this area, this presents a big challenge to us.'

However, such challenges are to be expected when something as novel and unique as Dr Inventor comes about and, given how many people from various sectors are involved, the challenges will more than likely be met sooner rather than later. Ultimately, in realising the ambitions of the project, Dong and his team hope to strike a balance between man and machine – one that takes individual scientific creative processes and marries them with innovative technologies to help individuals not only realise the potential of their research undertakings, but to perhaps come across a mode of thought or style of approach that they otherwise would not have done.

Once the system has gained widespread acceptance by research communities across Europe, many opportunities for a wide variety of sectors will open up and lead to discoveries that are, now at least, unimaginable.

Project Insights

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DRINVENTOR