Bangor University AIMLAC PhD projects 2023

Project 1. Visualisation of law using Artificial Intelligence

Supervisor: Dr Pete Butcher, School of Computer Science and Electronic Engineering, Bangor University
2nd supervisor: Professor Jonathan C. Roberts, School of Computer Science and Electronic Engineering, Bangor University
3rd supervisor: Dr Sarah Nason. School of Law, Bangor University

Research theme: T3 - novel mathematical, physical and computer science approaches

Project description: This project will ideate, design and programme computing solutions to apply visualisation techniques to legal advice services, underpinned by AI (Artificial Intelligence). Access to legal information and advice is a complicated and sometimes expensive process. An increasing number of legal services are being offered online, for free with the aim of making it easier for anyone to get access to the legal information they need (E.g., Resolver, Legal Utopia). Many of these systems, including those developed by us [1], require massive amounts of time and effort in the background, scouring legal code to produce simplified flow diagrams describing the connections between legal bodies and their processes. Artificial Intelligence (AI) techniques have the potential to help capture, organise, and analyse this material automatically. The use of artificial intelligence (AI) can help reduce the workload required by the humans in the loop behind the scenes. Data-visualisation has potential to elicit salient information to the public. For example, current legal visualisation research has tended to focus on litigation and private and commercial issues, whereas visualising public law (the law that governs relationships between individuals and public bodies) and the nature of law as pathways and visualising the reasoning or decision-making processes inherent to law, and the stories of those subject to law, remain under-explored aspects of legal design.

The work will design and implement data-visualization solutions that will help laypeople and policy makers alike understand the systems in which they are operating. The work will involve working as a team, and speaking with lawyers, ombudsmen, legal services, advisors etc. It will require the development of mathematically driven AI analysis solutions, and human-in-the-loop computing interfaces.

[1] J. C. Roberts, P. Butcher, A. Sherlock, and S. Nason. "Explanatory Journeys: Visualising to Understand and Explain Administrative Justice Paths of Redress", IEEE Trans. on Vis. and Computer Graphics, vol. 28 1, 2022, pp. 518-528, DOI: 10.1109/TVCG.2021.3114818

Project 2. Artificial Intelligence in IoT Full stack (Internet of Things) for Enviromental Science

Supervisor: Dr Noel Bristow, School of Computer Science and Electronic Engineering, Bangor University
2nd supervisor: Dr Panagiotis Ritsos, School of Computer Science and Electronic Engineering, Bangor University
3rd supervisor:

Research theme: T3 - novel mathematical, physical and computer science approaches

Project Description.

Modern IoT (Internet of Things) data capture, storage and visualisation confront the developer and analysts with severe data challenges: massive volumes, rapidly changing, temporal, spatial, contaminated, wide, imbalanced (and so on). But the use of IoT environmental data has huge opportunities to help scientists understand the natural world, how the climate is changing, and influence policy makers [1-3]. This project will seek to develop novel and effective solutions where standard approaches are ineffective. The work will investigate theoretical and practical solutions that will transfer across from computing to application domains in computer science and environmental science and oceanography. One solution could focus on solutions to weakly supervise learning, within a full-stack framework. This could be used to extract actionable insights from the digital streams, reducing the volume of data stored, and enhancing visualisation. Consequently, the work requires expertise in coding but also full-stack development. We will work with sensors, and Bangor's network of LoRaWAN gateways linked to The Things Network, developing IoT Full Stack solutions that combine the use of Front End (e.g., HTML, CSS, JavaScript) with Back End development (e.g., Python, PHP) with Internet of Things (firmware systems, networking protocol, and sensors) underpinned with AI learning solutions. Experiments will be carried out to explore learnt analysis of techniques to highlight and store salient features and learnt behaviour and visualise the results to the end-user. We will work alongside various partners at Bangor University: electronics engineers to develop IoT sensors; and environmental scientists to enable the development of robust solutions for the challenges they face. This project, by developing an intelligent IoT pipeline, enhanced with AI, will provide the infrastructure to enable these challenges to be met.

[1] Zhang, S., Bristow, N., David, T. W., Elliott, F., O'Mahony, J., & Kettle, J. (2022). "Development of an organic photovoltaic energy harvesting system for wireless sensor networks; application to autonomous building information management systems and optimisation of OPV module sizes for future applications", *Solar Energy Materials and Solar Cells*, *236*, 111550.

[2] A. M. F. Rigby, P. W. S. Butcher, P. D. Ritsos, and S. D. Patil, "LUCST: A novel toolkit for Land Use Land Cover change assessment in SWAT+ to support flood management decisions", *Environmental Modelling & Software*, no. 105469, Aug. 2022.

[3] Bristow, N., Rengaraj, S., Chadwick, D., Kettle, J., & Jones, D., "Development of a LoRaWAN IoT Node with Ion-Selective Electrode Soil Nitrate Sensors for Precision Agriculture", *Sensors*, (accepted November 2022).

Project 3: AI driven data-visualisation design and storytelling

Supervisor: Prof. Jonathan Roberts School of Computer Science and Electronic Engineering, Bangor University
2nd and 3rd supervisor: Dr Pete Butcher, and Dr Panagiotis Ritsos, School of Computer Science and Electronic Engineering, Bangor University

Research theme: T3 - novel mathematical, physical and computer science approaches

Visualising data is a creative process yet challenging. Showing the most important results, highlighting the most significant correlations, and displaying data in an effective way can be challenging for any researcher. Often researchers create visualisations and make presentations (telling stories with their data) to highlight the important lessons learnt. Our recent work has focused on design [1], layout techniques [2], and telling visualisation stories [3]. AI algorithms have the potential to extract salient features and remove effort of design and storytelling presentation. Potentially exemplars can be used to train the system. Teachers often explain and describe best practices. But while there are many examples, this is tacet knowledge and it is difficult to articulate what 'best' means. Local search solutions and weak supervision can help. Label placement algorithms use local searches (such as performed through a Tabu search), and we semi-automatically present stories of covid data, highlighting salient features [3]. But deep learning has the potential to go further, and suggest appropriate designs, guide researchers in design decision making, re-engineer design solutions, highlight salient features and provide appropriate visualisations, inspire design ideation processes, and so on. We will investigate weak supervision, semi-supervised learning, transudative learning and deep learning. Focus will be on both automatic design and the presentation of the information in automatic storytelling. Learning from current exemplar research, it will research algorithms, metrics, and methods to help researchers design visualisations and use them to tell effective stories with their data.

[1] Roberts, J. C., Headleand, C., & Ritsos, P. D. (2015). Sketching Designs Using the Five Design-Sheet Methodology. IEEE Transactions on visualization and computer graphics, 22(1), 419-428.

[2] Chen X, Zeng W, Al-Maneea HMA, Roberts JC, Chang R. (2021). Composition and Configuration Patterns in Multiple-View Visualizations. IEEE Transactions on visualization and computer graphics. 27(2):1514-1524.

[3] M. Chen, A. Abdul-Rahman, D. Archambault, J. Dykes, A. Slingsby, P. D. Ritsos, T. Torsney-Weir, C. Turkay, B. Bach, R. Borgo, A. Brett, H. Fang, R. Jianu, S. Khan, R. S. Laramee, P. H. Nguyen, R. Reeve, J. C. Roberts, F. Vidal, Q. Wang, J. Wood, and K. Xu, "RAMPVIS: Answering the Challenges of Building Visualisation Capabilities for Large-scale Emergency Responses," Epidemics, vol. 39, no. 100569, Jun. 2022.