



## Professor Weiru Liu

Professor of Artificial Intelligence

### Area of research

AI, Data Analytics, Intelligent Autonomous Systems

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### Summary

Short Bio:

Weiru Liu holds Chair of Artificial Intelligence (AI) at the University of Bristol, and is the Engineering Faculty Research Director. Prior to joining the University of Bristol in 2017, she held the Chair of AI at Queen's University Belfast (QUB), and was the Director of Research for the Knowledge and Data Engineering Research Cluster for 6 years. She has a sustained track record of securing peer-reviewed, highly competitive funding from a diverse range of funding bodies (over £35.5m as Principal Investigator or Co-Investigator).

She is a member of UK EPSRC ICT Strategic Advisory Team (ICT SAT); a member of UK Higher Education Research Excellence Framework (REF2021) Institutional Environment Pilot Panel; a member of an international committee for Independent Research Fund Denmark (DFF) - Digital Technologies; and a Co-Director for the EPSRC Centre for Doctoral Training in Future Autonomous and Robotic Systems: Towards Ubiquity (FARSCOPE-TU), 2019-2028.

Research Interests:

Her research interests include: data-driven intelligent autonomous systems; cyber-physical systems; large-scale sensor network data analytics, and event modelling, reasoning and correlation in uncertain environments in sensor networks; and information fusion under uncertainty, with a wide range of applications such as security, healthcare, robotics. She has published over 200 peer-reviewed papers, chaired several international conferences, and was an invited keynote at a few international conferences.

#### 1. Intelligent Autonomous Systems

Our theoretical research includes uncertain information modelling and fusion; event correlation and reasoning; belief modelling and revision; online planning under uncertainty; multi-criteria decision making under uncertainty. Specifically

- Developing multi-agent based, data-driven event reasoning frameworks for correlating dispersed events detected from heterogeneous sources in a distributed complex environment for achieving situation awareness. Applications include intelligent surveillance in cyber-physical systems, smart homes, and intelligent energy and transport management in smart cities.
- Developing intelligent autonomous systems using multi-agent techniques for complex control problems and for designing collaborative (software) agents, or mixed teams of multi-robots and human for working together in complex environment. Applications include smart cities, services, complex industrial control problems, and games for entertainment or education.
- Handling ambiguous evidence in *game theory* for security and multi-criteria decision making under uncertainty in complex systems.
- Modelling, reasoning, and merging uncertain information from heterogeneous sources in any intelligent systems (e.g., large sensor networks). We particularly focus on the *Dempster-Shafer theory of Evidence (belief function theory)*, *possibility theory and possibilistic logic*, and *probability theory*.

## 2. Data mining, large-scale data analytics, anomaly/threats detection

We develop Machine Learning and Data Mining algorithms to discover knowledge. Recent work has been focusing on graph-based approaches for both historic and streaming data analytics, with numerous applications.

- Developing anomaly detection algorithms for detecting abnormal behaviours (anomalies) in physical access control environment under the context of security.
- Developing graph-based algorithms for identifying exercise patterns and influences among participants in events.
- Discovering social connection patterns from social networks with streaming data.
- Developing various data analytical approaches, in collaboration with Belfast City Council, for analyzing data on CityBikes, Pollution, Waste disposal/treatment, Recycling; Anti-Social Behaviours, etc.
- Developing real-time threats and anomaly prediction algorithms with missing values in datasets, using knowledge discovered above, to provide real-time situation awareness for decision support.

## 3. Theoretical aspects of Merging/Revising Uncertain and Inconsistent Knowledgebases

Our research includes developing fusion methods (merging operators) and algorithms for merging multiple knowledgebases (maybe with constraints), especially, *propositional and possibilistic knowledgebases, stratified knowledgebases, imprecise probabilistic logic based knowledge bases, and heterogeneous uncertain information*. We also develop revision strategies/operators for revising such knowledge/belief bases.

Recent research has progressed to providing a toolkit for identifying minimal inconsistent subsets and calculating inconsistency values of knowledgebases or individual formulae in large-scale knowledge bases. This research has also been extended to developing approaches for detecting inconsistencies in probabilistic knowledge bases (learned by other machine learning systems) and repairing such inconsistencies.

## Memberships

### Organisations

[Department of Engineering Mathematics](#)

### Other sites

- [Engineering-mathematics](#)

### Research Groups

- [Robotics](#)
- [Intelligent Systems - Core](#)

## Recent publications

- Xu, M, McAreavey, K, Bauters, K & Liu, W, 2019, '[Intention Interleaving Via Classical Replanning](#)'. in: *2019 31st International Conference on Tools with Artificial Intelligence*. Institute of Electrical and Electronics Engineers (IEEE)
- Huang, G, Jiang, Y, Ma, W & Liu, W, 2019, '[Assessing semantic similarity between concepts using Wikipedia based on nonlinear fitting](#)'. in: Randy Goebel, Yuzuru Tanaka, Wolfgang Wahlster (eds) *The 12th International Conference on Knowledge Science, Engineering and Management (KSEM 2019)*. Springer, pp. 159-171
- Coraggio, E, Han, D, Liu, W & Tryfonas, T, 2019, '[Hydroinformatics of Smart Cities: Real-time water quality monitoring and prediction](#)'.
- McAreavey, K, Bauters, K, Liu, W & Hong, J, 2019, '[Branching-Bounded Contingent Planning via Belief Space Search](#)'. in: *2nd ICAPS Workshop on Explainable AI Planning (XAIP'19)*.
- Xu, M, Bauters, K, McAreavey, K & Liu, W, 2019, '[A Framework for Plan Library Evolution in BDI Agent Systems](#)'. in: *2018 IEEE 30th International Conference on Tools with Artificial Intelligence (ICTAI 2018): Proceedings of a meeting held 5-7 November 2018, Volos, Greece*. Institute of Electrical and Electronics Engineers (IEEE), pp. 414-421
- Ma, W, McAreavey, K, Liu, W & Luo, X, 2018, '[Acceptable costs of minimax regret equilibrium: A Solution to security games with surveillance-driven probabilistic information](#)'. *Expert Systems with Applications*, vol 108., pp. 206-222
- Xu, M, Bauters, K, McAreavey, K & Liu, W, 2018, '[A Formal Approach to Embedding First-Principles Planning in BDI Agent Systems](#)'. in: *Scalable Uncertainty Management: 12th International Conference, SUM 2018, Milan, Italy, October 3-5, 2018, Proceedings*. Springer Nature, pp. 333-347
- Spratt, CT, Hong, J, McAreavey, K & Liu, W, 2018, '[Community-based measures for social capital](#)'. in: Luca Maria Aiello, Hocine Cherifi, Pietro Lió, Luis M Rocha, Chantal Cherifi, Renaud Lambiotte (eds) *Complex Networks and Their Applications VII: Volume 2 Proceedings The 7th International Conference on Complex Networks and Their Applications COMPLEX NETWORKS 2018*. Springer, Cham, pp. 327-338
- Ma, W, Jiang, Y, Liu, W, Luo, X & McAreavey, K, 2018, '[Expected Utility with Relative Loss Reduction: A Unifying Decision Model for Resolving Four Well-Known Paradoxes](#)'. in: *32nd AAAI Conference on Artificial Intelligence (AAAI'18)*. AAAI Press, pp. 687-695
- Killough, R, Bauters, K, McAreavey, K, Liu, W & Hong, J, 2018, '[Resource-based Dynamic Rewards for Factored MDPs](#)'. in: *2017 IEEE 29th International Conference on Tools with Artificial Intelligence (ICTAI 2017): Proceedings of a meeting held 6-8 November 2017, Boston, Massachusetts, USA*. Institute of Electrical and Electronics Engineers (IEEE), pp. 1320-1327

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