



# UKCI 2019

**Conference Programme  
The 19th Annual UK Workshop on Computational  
Intelligence**

**4-6 September 2019  
University of Portsmouth, Portsmouth, UK**

**[www.ukci2019.port.ac.uk](http://www.ukci2019.port.ac.uk)**

Organised and Sponsored by:



# Welcome to UKCI 2019!

The 19th Annual UK Workshop on Computational Intelligence is held at the University of Portsmouth. UKCI series has been one of the most important academic meetings in the field of computational intelligence in the UK and continuously supported by Springer. This year, the UKCI 2019 is held in conjunction with EDMA 2019, the 3rd International Engineering Data- and Model-Driven Applications Workshop.

The UKCI 2019 covers both theory and applications in computational intelligence systems and has been most successful in attracting a total of 63 submissions addressing the state-of-the-art development and research covering topics related to Fuzzy Systems, Intelligence in Robotics, Deep Learning Approaches, Optimisation and Classification, Detection, Inference and Prediction, Hybrid Methods, Emerging Intelligence, Intelligent Healthcare and Engineering Data- and Model-Driven Applications. Following the rigorous reviews of the submissions, a total of 45 papers (71% acceptance rate) were selected to be presented in the conference during September 6-8, 2019. We hope that the published papers of the UKCI 2019 will prove to be technically constructive and helpful to the research community of computational intelligence.

We would like to express our sincere acknowledgment to the attending authors and the 5 distinguished plenary speakers. The acknowledgment is also given to the UKCI 2019 programme committee for their efforts in the rigorous reviewing process. Special thanks are extended to Dalin Zhou in appreciation of his contribution in the organisation throughout the UKCI 2019. Last but not least, the help from Rini Christy and Thomas Ditzinger of Springer is appreciated for the publishing.

We hope that you enjoy the academic discussions and the waterfront city of Portsmouth.

**Zhaojie Ju**

General Chair of UKCI 2019



Han Liu	Cardiff University
Honghai Liu	University of Portsmouth
Katrin Lohan	Heriot-Watt University
Ahmad Lotfi	Nottingham Trent University
Trevor Martin	Bristol University
Martin McGinnity	Nottingham Trent University
Mufti Mahmud	Nottingham Trent University
Lyudmila Mihaylova	University of Sheffield
Daniel Neagu	University of Bradford
Gabriela Ochoa	University of Stirling
Djamila Ouelhadj	University of Portsmouth
Anna Palczewska	Leeds Beckett University
George Panoutsos	University of Sheffield
Amir Pourabdollah	Nottingham Trent University
Girijesh Prasad	University of Ulster
Chris Price	Aberystwyth University
Shahin Rostami	Bournemouth University
Steven Schockaert	Cardiff University
Qiang Shen	Aberystwyth University
Yuichiro Toda	Okayama University
Chenguang Yang	University of the West of England
Longzhi Yang	Northumbria University
Shengxiang Yang	De Montfort University
Shufan Yang	University of Glasgow
Yingjie Yang	De Montfort University
Christine Zarges	Aberystwyth University

### **Organising Committee of EDMA 2019**

Felician Campean	University of Bradford
Marian Gheorghe	University of Bradford
Daniel Neagu	University of Bradford

### **Technical Committee of EDMA 2019**

Gongde Guo	Fujian Normal University
Jon Hall	Open University
Ci Lei	University of Bradford
Francesco Masulli	University of Genoa
Paul Trundle	University of Bradford
Longzhi Yang	Northumbria University
Sandra Gomez Canaval	Technical University of Madrid
Mohammed Reza Kianifar	Caterpillar/ Perkins Energy Systems
Alberto Cabri	University of Genoa
David Richardson	Jaguar Land Rover
Unal Yildirim	University of Bradford

# Conference Information

## Registration

The registration desk will be open during following times on the ground floor of the conference venue.

- Tuesday 3 September, 12:00-17:00
- Wednesday 4 September, 08:30-17:00
- Thursday 5 September, 08:30-15:00

## Internet

During the period of the conference, standard access to Internet is available within the conference venue. If you don't have the access to the eduroam, to access the WiFi in the University of Portsmouth, please select "UoP GUEST" from the list of options and follow the instructions.

## Presentation guidelines

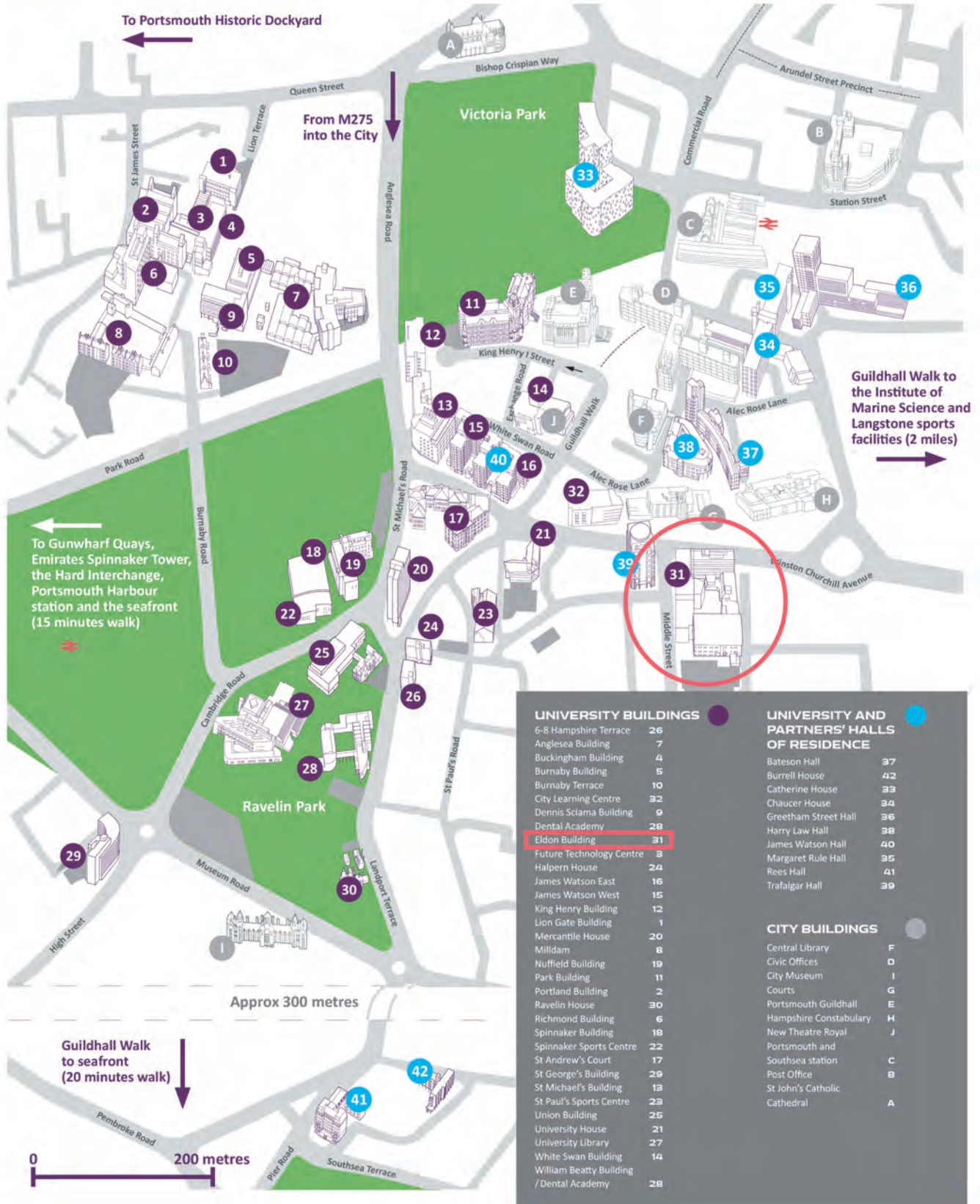
A 15-minute oral presentation is arranged for each paper in oral sessions including a 12 minutes' slides and 3 minutes' Q&A. It is expected that you bring your own PowerPoint slides to the conference either with/without your personal laptop. The desktop/laptop, the projector, the display port/cable and the wireless presenter will be provided by our staff in oral sessions.

## Venue

The conference venue will be Eldon Building in the University of Portsmouth, PO1 2DJ, Portsmouth.



# UNIVERSITY OF PORTSMOUTH



UNIVERSITY BUILDINGS		UNIVERSITY AND PARTNERS' HALLS OF RESIDENCE	
6-8 Hampshire Terrace	26	Bateson Hall	37
Anglesea Building	7	Burrell House	42
Buckingham Building	4	Catherine House	33
Burnaby Building	5	Chaucer House	34
Burnaby Terrace	10	Greatham Street Hall	36
City Learning Centre	32	Harry Law Hall	38
Dennis Scama Building	9	James Watson Hall	40
Dental Academy	28	Margaret Rule Hall	35
<b>Eldon Building</b>	<b>31</b>	Rees Hall	41
Future Technology Centre	3	Trafalgar Hall	39
Halpern House	24		
James Watson East	16		
James Watson West	15		
King Henry Building	12		
Lion Gate Building	1		
Mercantile House	20		
Milldam	8		
Nuffield Building	19		
Park Building	11		
Portland Building	2		
Ravelin House	30		
Richmond Building	6		
Spinnaker Building	18		
Spinnaker Sports Centre	22		
St Andrew's Court	17		
St George's Building	29		
St Michael's Building	13		
St Paul's Sports Centre	23		
Union Building	25		
University House	21		
University Library	27		
White Swan Building	14		
William Beatty Building / Dental Academy	28		

CITY BUILDINGS	
Central Library	F
Civic Offices	D
City Museum	I
Courts	G
Portsmouth Guildhall	E
Hampshire Constabulary	H
New Theatre Royal	J
Portsmouth and Southsea station	C
Post Office	B
St John's Catholic Cathedral	A

# Keynote Talks

**Prof Yaochu Jin, University of Surrey**

**Title: Communication Cost Sensitive Federated Learning**

## Abstract:

Federated learning is a new learning paradigm for decentralized privacy-preserving machine learning. Instead of communicating data from the end devices such as mobile phones to the cloud, local models are trained on the local devices and a global model is generated by aggregating the local models communicated from the end devices. In federated learning, communication efficiency as well as the performance of the global model is of great importance. In this talk, I will present two recently proposed algorithms that can reduce the communication costs without degrading the performance of the global model. The first algorithm simultaneously minimizes the communication costs and classification error by optimizing the architecture of the local models using a multi-objective evolutionary algorithm. The second algorithm introduces an asynchronous update strategy together with a temporally weighted aggregation. Empirical results on commonly used datasets demonstrate the effectiveness of the proposed algorithms.

## Profile:

Yaochu Jin received the B.Sc., M.Sc., and Ph.D. degrees from Zhejiang University, Hangzhou, China, in 1988, 1991, and 1996, respectively, and the Dr.-Ing. degree from Ruhr University Bochum, Germany, in 2001.

He is currently a Distinguished Chair and Professor in Computational Intelligence, Department of Computer Science, University of Surrey, Guildford, U.K., where he heads the Nature Inspired Computing and Engineering Group. He was a Finland Distinguished Professor funded by the Finnish Funding Agency for Innovation (Tekes) and a Changjiang Distinguished Visiting Professor appointed by the Ministry of Education, China. His main research interests include data-driven surrogate-assisted evolutionary optimization, evolutionary learning, interpretable and secure machine learning, and evolutionary developmental systems. His research has been funded by EU, EPSRC, Royal Society, NSFC, and the industry, including Honda, Airbus, and Bosch. He was elevated to IEEE Fellow for his contributions to evolutionary optimization.

Dr Jin is the Editor-in-Chief of the IEEE TRANSACTIONS ON COGNITIVE AND DEVELOPMENTAL SYSTEMS and Co-Editor-in-Chief of Complex & Intelligent Systems. He is an IEEE Distinguished Lecturer (2013-2015 and 2017-2019) and past Vice President for Technical Activities of the IEEE Computational Intelligence Society (2014-2015). He is the recipient of the 2018 IEEE Transactions on Evolutionary Computation Outstanding Paper Award, the 2015 and 2017 IEEE Computational Intelligence Magazine Outstanding Paper Award, and the Best Paper Award of the 2010 IEEE Symposium on Computational Intelligence in Bioinformatics and Computational Biology.

# Prof Alexandra Cristea, Durham University

## Title: Learning Analytics - where is it now and where is it going?

### Abstract:

Computational Intelligence is currently a thriving area and is applied to many fields. Within this, an emerging important area is that of learner analytics, a new field enabled by the recent advances in analytical and visualisation tools for big data, and the improved data formats and advances in computing technology [according to the Higher Education Academic in UK]. Learner Analytics refers to the measuring, collecting and analysis of data about learners and their environments, with the aim of improving teaching and learning practices, usually in online environments. This talk uncovers this exciting new field of research, discussing challenges, success stories, specific aims and goals in the context of education, and future developments. Some recent results on MOOCs are also presented.

### Profile:

Alexandra I. Cristea is Professor, Head of the Innovative Computing research group at the Computer Science Department, Durham University. Her research includes user modelling and personalisation, web science, learning analytics, semantic web, social web, authoring, with over 250 papers on these subjects (over 3700 citations on Google Scholar, h-index 31). Especially, her work on frameworks for adaptive systems has influenced many researchers and is highly cited (with the top paper with over 180 citations and growing). She is within the top 50 researchers in the world in the area of educational computer-based research according to Microsoft Research. Prof. Cristea has been highly active and has an influential role in international research projects. She is experienced in running research projects and has led various projects - Newton funded workshop on Higher Education for All ('14-'18), Santander funded Education for disadvantaged pupils ('14-'18'), Warwick-funded project APLIC ('11-'12), EU Minerva projects ALS (06-09) and EU Minerva ADAPT ('02-'05); as well as participated as university PI in several EU FP7 projects - BLOGFOREVER ('11-'13), GRAPPLE ('08-'11), PROLEARN ('07) and as co-PI in the Warwick-funded Engaging Young People with Assistance Technologies ('13-'15) also featured by the BBC.



# **Prof Gabriela Ochoa, University of Stirling**

## **Title: Artificial Evolution and Complexity: A visual Perspective**

### **Abstract:**

The intricacy and beauty of natural behaviours and shapes have inspired computational methods to understand and predict them, while Natural Evolution has inspired powerful computational problem-solving methods. We illustrate these two fields, Complexity and Evolutionary Computation, with a series of visual examples and metaphors; from the artificial evolution of plant-like structures to the automated design of transportation routes, educational timetables, and medical treatments.

### **Profile:**

Prof Ochoa is a Professor in Computing Science at the University of Stirling, Scotland. She received BSc and MSc degrees in Computer Science from University Simon Bolivar, Venezuela and a PhD from University of Sussex, UK. She worked in industry for 5 years before joining academia, and has held faculty and research positions at the University Simon Bolivar, Venezuela and the University of Nottingham, UK. Her research interests lie in the foundations and application of evolutionary algorithms and heuristic search methods, with emphasis on autonomous (self-\*) search, hyper-heuristics, fitness landscape analysis, and applications to combinatorial optimisation, healthcare, and software engineering. She has published over 100 scholarly papers and serves various program committees. She is associate editor of the IEEE Transactions on Evolutionary Computation, and the Evolutionary Computation Journal (MIT Press); and member of the Editorial Board for Genetic Programming and Evolvable Machines. She proposed the he first Cross-domain Heuristic Search Challenge (CHeSC 2011), has served as organiser and/or program chair for EvoCOP 2014, EvoCOP 2015, FOGA 2015, PPSN 2016, and served as the Editor-in-Chief for GECCO 2017.

# Prof Trevor Martin, University of Bristol

## Title: Approximately Right is Better Than Precisely Wrong

### Abstract:

In recent years, the data-driven model of AI has underpinned an expansion of intelligent systems into a wide range of applications, and many autonomous AI systems perform tasks without significant human input. Examples include product recommendation, game-playing, control of appliances and driverless vehicles. In contrast, collaborative intelligent systems aim to use the complementary strengths of humans and computers in partnership for tasks such as assisted driving, computer-aided diagnosis and complex data analysis tasks such as enhancing the security of information systems, networks and devices.

In this talk, I will emphasise the need for cybersecurity systems to be based on human-computer collaboration, rather than on computer autonomy. Human analysts can provide insight and interpretation, while machines perform data collection, repetitive processing and visualisation.

An important aspect of collaborative intelligence is the common definition of terms used by humans and machines to identify and categorise the data. In this talk we will argue that graded concepts (based on fuzzy set theory) are a natural framework for the interaction and exchange of information between analysts and machines. We will describe a new approach to approximate (fuzzy) categorisation, and outline examples where this assists collaborative intelligence.

### Profile:

Prof Martin is a Professor of Artificial Intelligence at the University of Bristol. Since 2001, he has been funded by BT as a Senior Research Fellow, researching soft computing in intelligent information management including areas such as extraction and integration of semi-structured information, soft concept hierarchies, the semantic web and user modelling. He is a member of the editorial board of Fuzzy Sets and Systems, and has served on many conference programme and organising committees. He is a co-organiser of the Uncertain Reasoning for the Semantic Web (URSW) series of workshops, and was active in a W3C group investigating the same topic as well as chairing the IEEE Computational Intelligence Society's Semantic Web Task Force. He has published over 200 papers in refereed conferences, journals and books, and is a Chartered Engineer and member of the BCS and IEEE, as well as serving on the UK EPSRC College.

# Prof Ahmad Lotfi, Nottingham Trent University

## Title: Ambient Computational Intelligence

### Abstract:

Computing will become transparent to humans and naturally involved in our everyday living. Ambient Computing refers to a digital environment that proactively supports people in their daily lives. It is an emerging discipline that brings intelligence to our living environments, makes those environments sensitive to us, and adapting according to the user's needs. By enriching an environment with appropriate sensors and interconnected devices, the environment would be able to sense changes and support decisions that benefit the users of that environment. Such smart environments could help to reduce energy consumption and thus the cost of facilities, improve safety and security, while at the same time increase user's comfort. One specific area of interest is the application of ambient computing in Assisted Living, where the home environment provides assistance with daily living activities for people with different cognitive and physical disabilities. To enhance the intelligence of the environment, Computational Intelligence techniques as a set of nature-inspired computational methodologies are available to address such complex problems for which traditional approaches are ineffective. This talk will provide a review of the technologies and environments that comprise ambient computing.

### Profile:

Prof Lotfi is a Professor of Computational Intelligence at School of Science and Technology, Nottingham Trent University, Nottingham, United Kingdom. He has made a significant contribution to the application of intelligent control and robotic systems using soft computing techniques. He has a comprehensive background in the Supervision and Teaching of undergraduate and research students and the development of research programs in theory and application of control systems. Also, strong communications and decision-making skills with a make-it-happen ability to organise, manage and motivate multi-disciplinary teams at the technical and academic levels to meet targeted objectives. His research interests include but not limited to; Computational Intelligence, Ambient Computing (Smart Home and Smart Environment), Robotics, Wireless Sensor Network, Intelligent Modeling and Control, Data Mining, Learning Fuzzy Systems, Condition Monitoring and Intelligent Data Analysis.

# Programme at a glance

## 4 September

08:30-17:00	Conference Registration
08:30-09:00	Arrival Refreshment
08:50-09:00	Welcome and Opening
09:00-10:00	Keynote Talk 1: Prof Yaochu Jin
10:00-11:00	Keynote Talk 2: Prof Alexandra Cristea
11:00-11:15	Refreshment
11:15-12:30	Session 1: Deep Learning Approaches
12:30-13:30	Lunch
13:30-14:15	Session 2: Intelligence in Robotics
14:15-16:00	Session 3: Detection, Inference and Prediction
16:00-16:15	Refreshment
16:15-17:45	Session 4: EDMA 2019 Special Session Engineering Data- and Model-Driven Applications
17:45-18:45	Session 5: Emerging Intelligence

## 5 September

08:30-15:00	Conference Registration
08:30-09:00	Arrival Refreshment
09:00-10:00	Keynote Talk 3: Prof Gabriela Ochoa
10:00-11:00	Keynote Talk 4: Prof Trevor Martin
11:00-11:15	Refreshment
11:15-12:00	Session 6: Intelligent Healthcare
12:00-12:45	Session 7: Hybrid Methods
12:45-13:30	Lunch
13:30-14:30	Keynote Talk 5: Prof Ahmad Lotfi
14:30-15:45	Session 8: Fuzzy Systems
15:45-16:00	Refreshment
16:00-17:45	Session 9: Optimisation and Classification
17:45-18:15	Business Session for UKCI Proposals
18:30-	Conference Dinner and Closing

# Sessions

**Wednesday, 4th September**

**Keynote Talk 1: Prof Yaochu Jin**

**09:00-10:00**

**Communication Cost Sensitive Federated Learning**

**Keynote Talk 2: Prof Alexandra Cristea**

**10:00-11:00**

**Learning Analytics - where is it now and where is it going?**

**SESSION 1: Deep Learning Approaches**

**11:15-12:30**

- **Edvinas Byla and Wei Pang:** DeepSwarm: Optimising Convolutional Neural Networks using Swarm Intelligence
- **Gulrukh Turabee, Yuan Shen and Georgina Cosma:** Investigating and Interpreting the Filters in the First Layer of a Convolutional Neural Network for Sleep Stage Classification
- **Jialin Liu, Chih-Min Lin and Fei Chao:** Gradient Boost with Convolution Neural Network for Stock Forecast
- **Xueyi Wang, Tianqi Xie and Longbiao Chen:** Urban Village Identification from City-Wide Satellite Images Leveraging Mask R-CNN
- **Davis Agyemang and Mohamed Bader:** Surface Crack Detection Using Hierarchical Convolutional Neural Network

LUNCH

**SESSION 2: Intelligence in Robotics**

**13:30-14:15**

- **Jing Luo, Chao Liu, Ning Wang and Chenguang Yang:** A method of Intention Estimation for Human-Robot Interaction
- **Yanan Li and Chenguang Yang:** A Hybrid Human Motion Prediction Approach for Human-Robot Collaboration
- **Quanfeng Li, Chao Fei, Xingen Gao, Longzhi Yang, Chih-Min Lin, Changjing Shang and Changle Zhou:** A Robotic Chinese Stroke Generation Model based on Competitive Swarm Optimizer

### SESSION 3: Detection, Inference and Prediction

14:15-16:00

- **Jordan J. Bird, Aniko Ekart and Diego R. Faria:** Phoneme Aware Speech Synthesis via Fine Tune Transfer Learning with a Tacotron Spectrogram Prediction Network
- **Kieran Stone, Reyer Zwiggelaar, Phil Jones and Neil Mac Parthaláin:** Predicting Hospital Length of Stay for Accident and Emergency Admissions
- **Daniel Dimanov and Shahin Rostami:** KOSI- Key Object Detection for Sentiment Insights
- **Fatima Chiroma, Mihaela Cocea and Han Liu:** Detection of Suicidal Twitter Posts
- **Ramazan Esmeli, Mohamed Bader-El-Den and Hassana Abdullahi:** Improving Session Based Recommendation by Diversity Awareness
- **Yu Yao, Dongliang Cheng, Gang Peng and Xuejuan Huang:** Fault Prognosis Method of Industrial Process Based on PSO-SVR
- **Ahmed Abubahia, Salem Chakhar and Mihaela Cocea:** Preference Learning based Decision Map Algebra: Specification and Implementation

### SESSION 4: EDMA 2019 Special Session Engineering Data- and Model-Driven Applications

16:15-17:45

- **Denis Torgunov, Paul Trundle, Felician Campean and Daniel Neagu:** Vehicle Warranty Claim Prediction from Diagnostic Data using Classification
- **Zied Mnasri, Stefano Rovetta and Francesco Masulli:** Feature analysis for emotional content comparison in speech
- **Gaurav Pant, Felician Campean, Aleksandrs Korsunovs and Daniel Neagu:** Co-Modelling Strategy for Development of Airpath Metamodel on Multi-Physics Simulation Platform
- **Natasha Micic, Ci Lei, Daniel Neagu and Felician Campean:** Queries on Synthetic Images for Large Multivariate Engineering Data Base Searches
- **Noe Elisa, Longzhi Yang and Fei Chao:** Signal Categorisation for Dendritic Cell Algorithm using GA with Partial Shuffle Mutation
- **Han Pu, Tianqiang Huang, Bin Weng, Gongde Guo and Wei Huang:** Video tampering detection algorithm based on spatial constraints and stable feature

## SESSION 5: Emerging Intelligence

17:45-18:45

- **Will Serrano:** 5G Cybersecurity based on the Blockchain Random Neural Network in Intelligent Buildings
- **Will Serrano:** iBuilding: Artificial Intelligence in Intelligent Buildings
- **Huili Cai, Xiaofeng Liu and Bin Yan:** Beautified QR Code with Security Based on Data Hiding
- **Hongwei Wang, Yichun Yang and Yufei Zhang:** A Macro Human Resource Management Platform Enabled by Big Data Technology

## Thursday, 5th September

### Keynote Talk 3: Prof Gabriela Ochoa

09:00-10:00

**Artificial Evolution and Complexity: A visual Perspective**

### Keynote Talk 4: Prof Trevor Martin

10:00-11:00

**Approximately Right is Better Than Precisely Wrong**

### Keynote Talk 5: Prof Ahmad Lotfi

13:30-14:30

**Ambient Computational Intelligence**

## SESSION 6: Intelligent Healthcare

11:15-12:00

- **Jodie Ashford, Jordan J. Bird, Felipe Campelo and Diego R. Faria:** Classification of EEG Signals Based on Image Representation of Statistical Features
- **Yang Wei, Nadezhda Gracheva and John Tudor:** A non-invasive subtle pulse rate extraction method based on Eulerian video magnification
- **Xinyang Li, Balvinder Drbalvinderhanda, Nicholas Peters and Fu Siong Ng:** Classification of Fibrillation Subtypes with Single-Channel Surface Electrocardiogram



## SESSION 7: Hybrid Methods

12:00-12:45

- **Shengjie Sun and Yuan Shen:** "Parallel-Tempering"-assisted Hybrid Monte Carlo Algorithm for Bayesian Inference in Dynamical Systems
- **Nouf Alghanmi and Xiaojun Zeng:** A hybrid regression model for mixed numerical and categorical data
- **Nitin Naik and Qiang Shen:** Integration of Interpolation and Inference with Multi-antecedent Rules

LUNCH

## SESSION 8: Fuzzy Systems

14:30-15:45

- **Raheleh Jafari, Sina Razvarz, Alexander Gegov and Wen Yu:** Fuzzy Control of Uncertain Nonlinear Systems with Numerical Techniques
- **Gadelhag Mohamed, David Ada Adama and Ahmad Lotfi:** Fuzzy Feature Representation with Bidirectional Long Short-Term Memory for Human Activity Modelling and Recognition
- **Muhammad Ismail, Jing Yang, Changjing Shang and Qiang Shen:** Single Frame Image Super Resolution using ANFIS Interpolation: An Initial Experiment-Based Approach
- **Aiwen Meng, Hak-Keung Lam, Liang Hu and Fucai Liu:** L1-Induced Static Output Feedback Controller Design and Stability Analysis for Positive Polynomial Fuzzy Systems
- **Zheming Zuo, Jie Li and Longzhi Yang:** An Extended Curvature-based Rule Base Generation for Fuzzy Interpolation

## SESSION 9: Optimisation and Classification

16:00-17:45

- **Rhys Stubbs, Kevin Wilson and Shahin Rostami:** Hyper-parameter Optimisation by Restrained Stochastic Hill Climbing
- **Hadeel Albalawi, Wei Pang and George Coghil:** Swarm Inspired Approaches for K-prototypes clustering
- **Noe Elisa, Fei Chao and Longzhi Yang:** The Necessity of Signal Categorisation in Dendritic Cell Algorithm
- **Tingyu Xie, Gongzhuang Peng and Hongwei Wang:** Interval Construction and Optimization for Mechanical Property Forecasting with Improved Neural Networks
- **Sebastiano Cavallaro, Vincenzo Cutello, Mario F. Pavone, Rocco A. Scollo and Antonio M. Spampinato:** An Immunological Algorithm for Graph Modularity Optimization
- **Hoang Nhat Dau, Salem Chakhar, Djamila Ouelhadj and Ahmed M. Abubahia:** Construction and Refinement of Preference Ordered Decision Classes
- **Zainab Mutlaq Ibrahim, Mohamed Bader-El-Den and Mihaela Cocea:** Improving Imbalanced Text Classification Using Re-sampling Based Approach