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EDITORIAL

Special issue on neuro, fuzzy and their hybridization

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One of the most profound and influential endeavours in Artificial Intelligence is the development of inference systems in an effort to mimic human reasoning process, as evidenced by the long history of research, broad real-world applications, and powerful impact. Inference systems apply logical rules to the knowledge base to deduce new information. As a mode to conduct information that is not accurate, but rather uncertain, fuzzy sets provide conventional inference systems with a power to approximate human reasoning capabilities with the uncertainties associated with human cognitive processes. Consequently, fuzzy inference systems have been successfully applied to a wide range of benchmark and real-world application problems. The hybridization of fuzzy inference systems with related techniques, such as neural networks, granular computing and genetic algorithms, can synergize the fuzzy reasoning process with the connectionist structure, information granules and evolving parameter learning. The joint effort made by different computational paradigms leads to enhanced performance that can target the biggest challenges in many fields, such as engineering, cyber-physical systems, and health care.

This special issue showcases state-of-the-art works in the field of fuzzy inference systems that are synergized with other computational intelligence techniques, such as neural networks, granular computing, and genetic algorithms, in an effort to inspire the development of the next generation of fuzzified systems. This special issue has attracted nearly 50 submissions and 12 manuscripts were selected based on review reports. Each paper was reviewed by at least two independent reviewers and went through at least two rounds of reviews. The contributions of these papers are briefed below.

The first contribution by Leandro Maciel et al. reports a novel adaptive fuzzy interval modelling approach for the forecast and prediction of future events using interval-valued time series. The proposed approach benefits from a rule base structure and parameters adaptation process which evolves the rules along with the feeding of new data inputs. This is implemented through the employment of participatory learning and guided by weighted recursive least squares. The proposed method was applied to predict the prices of four most traded cryptocurrencies, including BitCoin, Ethereum, XRP, and LiteCoin, with competitive results demonstrated.

The second paper by Xiaozhen Liang and Zhikun Wu also targets time series but with a specific application in the tourist industry. In particular, this paper proposes a two-stage approach by combining a dual decomposition strategy and an improved fuzzy time series method. The first stage uses a dual decomposition strategy to extract the key features of the tourist arrivals time series dataset. This is followed by the second stage which applies a fuzzy C-means-based time series method to discretize the data for prediction. The work was evaluated by applying the proposed approach on a monthly tourist arrivals dataset. The experimental results indicate the superiority of the proposed approach in reference to the benchmark models.

The third publication by Dinh Phamtoan and Tai Vovan presents a new model for time series by combining genetic algorithm and fuzzy modelling. In particular, the approach uses the genetic algorithm to determine the optimal number of clusters for a given time series, and a fuzzy relationship is then established for each cluster for time series prediction. A comparative study in reference to other existing

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approaches shows the stability and competitive performance of the proposed approach. This approach was particularly timely applied to the prediction of COVID-19 cases providing a well-timed analysis of the pandemic.

The fourth paper by Rajagopal Kumar et al. also targets the prediction of the spread of COVID-19 with a focus in India. The prediction was implemented by an adaptive neuro-fuzzy inference system based on a dataset collected in the first half of 2020. In addition to reporting the findings about the predicted COVID-19 cases, this study also recommended potential actions based on the analysis aiming to minimize the spread of the disease.

The fifth publication by Muhammad Ismail et al. presents a new approach for sparse data-based single frame image super-resolution. This is achieved by allowing interpolation in an adaptive network-based fuzzy inference system when the concerned dataset is sparse. After comparing with other image super-resolution approaches, the paper concludes that the proposed approach is robust and of good efficacy.

The sixth article by Murat Ince integrates the fuzzy analytic hierarchy process-genetic algorithm to a bi-directional long short-term memory approach for applications in the field of gaming. In particular, the proposed system was used to generate procedural game levels for environments in educational games. A comparative study in reference to the popular multi-criteria decision-making approaches demonstrates the effectiveness of the proposed approach for game level generation.

The seventh paper by P. Dillep et al. proposes a cluster-based bi-directional long short-term memory approach for the prediction of heart diseases. This approach uses the *K*-means clustering algorithm to avoid duplicate data instances in the datasets. The approach was applied to the UCI heart disease dataset and a real-time dataset, and the experimental results show better performance than other existing approaches.

The eighth paper by Suvra Jyoti Choudhury and Nikhil R. Pal proposes three methods using neural networks and evidential reasoning for the classification of incomplete dataset. The methods first generate the latent space representation of the data using an autoencoder, which are followed by the application of classifiers leading to the final classification results using evidence theory. The proposed methods were applied to both artificial and real datasets showing the superiority of the proposed methods.

The ninth paper by Xuhong Cheng et al. reports a hybrid control and prediction system particularly targeting the modelling of wastewater treatment processes where fuzziness presents as a great challenge. The system is realized by combining the activated sludge model, convolutional neural network, and long short-term memory neural networks implementing both knowledge and data-driven modelling. A comparative study in reference to five benchmark methods shows the stability of the proposed approach.

The article produced by Istvan A. Harmati et al. argues that some fuzzy cognitive maps require the property of global stability and reports some conditions for the global asymptotical stability of fuzzy cognitive maps. These conditions are generally simpler than the existing ones, and provide a more efficient upper bound on the parameter of the threshold function. The proposed conditions are compared with the ones available in the literature and the experimental results demonstrate the effectiveness of the proposed conditions.

The next article by Qianyu Liu et al. reports a self-optimization triggering mechanism to enable automated 5G network maintenance and enhance user mobility robustness in 5G heterogeneous networks. This system is developed based on the conventional fuzzy logic-based handover triggering mechanism algorithm by embedding the advantages of subtractive clustering and Q-learning frameworks. The proposed system was evaluated through a simulation with better performance demonstrated in comparison to its peers based on a number of common measures.

The final contribution by Surbhi Vijh et al. presents a tumour detection approach using brain MRI images. This approach firstly applies an extended Wiener filter, etc., to pre-process the image datasets leading to a set of features, which are then fed into a fuzzy weighted *K*-means embedded linear discriminant analysis process to select the prominent features. From this, an artificial neural network is employed to classify the images based on the presentation of tumours. The proposed approach was tested on standard benchmark datasets with promising outputs generated.

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Declarations

Conflict of interest The authors declare no conflicts of interest.