

Title

Fuzzy Networks for Explainable Artificial Intelligence

Presenters

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Abstract

This tutorial focuses on the inherent interpretability of fuzzy networks which makes them a suitable tool for building explainable artificial intelligence models. These models facilitate the identification of causal relationships between inputs and outputs by intermediate variables.

The tutorial highlights some recent research results of the presenters that have been published in 'IEEE Transactions on Fuzzy Systems', 'Fuzzy Sets and Systems', 'Intelligent and Fuzzy Systems', 'Computational Intelligence Systems', 'Uncertainty, Fuzziness and Knowledge Based Systems' and the Springer Book Series 'Studies in Fuzziness and Soft Computing'.

Fuzzy networks are similar to neural networks in terms of general structure but their nodes and connections are different. The nodes are fuzzy rule-based systems and the connections between these nodes are outputs from and inputs to these systems. Apart from being a structural counterpart for a neural network, a fuzzy network is also a conceptual generalisation of a fuzzy system and a bridge between two established types of fuzzy systems – flat and hierarchical.

Fuzzy networks have an underlying two-dimensional grid structure with horizontal levels and vertical layers. The levels represent spatial hierarchy in terms of network breadth and the layers represent temporal hierarchy in terms of network depth.

The nodes of fuzzy networks are modelled by Boolean matrices or binary relations. The connections between the nodes are modelled by block schemes or topological expressions. Each network node is located in a cell within the underlying grid structure.

Nodes in fuzzy networks are manipulated by merging and splitting operations. The merging operations are for network analysis and the splitting operations are for network design. These operations are used for converting a fuzzy network into a fuzzy system and vice versa.

The operations are illustrated on feedforward and feedback fuzzy networks. Feedforward networks include combinations of narrow/wide and shallow/deep network structures. Feedback networks include combinations of single/multiple and local/global feedback loops.

Fuzzy networks are applied to several benchmark examples and validated successfully against flat and hierarchical fuzzy systems. The validation uses performance evaluation indicators for feasibility, accuracy, efficiency, transparency.

In addition to the theoretical concepts above, the tutorial will present applications of fuzzy networks for business and finance, process control and transportation. The case studies from these application areas are benchmarked against flat and hierarchical fuzzy systems.