**Tutorial**

Title: Rule Based Systems and Networks: Deterministic and Fuzzy Approaches

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Abstract:

A rule based system is a special type of expert system which consists of a set of rules. In practice, rule based systems can be built by using expert knowledge or learning from real data. Due to the vast and increasing size of data, the latter approach has become quite popular for building rule based systems. In particular, rule based systems can be built through use of rule learning algorithms, which can be based on statistical heuristics or random basis.

The tutorial consists of two parts. The first part focuses on deterministic approaches for classification tasks. The second part features fuzzy approaches for modelling tasks. Both parts are concerned mainly with rule based systems that have a single rule base. However, some of the results are related to rule based networks that have multiple rule bases. In this context, a rule based system is considered as a special case of a rule based network whereas a rule based network is viewed as a generalisation of a rule based system.

The first part introduces a unified framework for design of deterministic rule based systems and networks, which consists of the operations of rule generation, rule simplification and rule representation. For each of the three operations, several existing and novel approaches are presented in detail for illustrative purposes. This part of the tutorial also stresses the importance of combination of different rule learning algorithms through ensemble learning approaches. In particular, the Bagging framework is described alongside several existing and novel approaches of ensemble learning in order to show how these approaches manage to improve overall performance of classification. In addition, a detailed systematic analysis of rule based systems is presented for the purpose of evaluating and improving their interpretability.

The second part introduces a unified framework for design of fuzzy rule based systems and networks, which consists of the approaches of rule base compression and modular rule bases. These two novel approaches are evaluated comparatively against the established approaches of rule base reduction and chained rule bases using appropriate theoretical metrics. This part of the tutorial also discusses the advantages of the proposed novel approaches with respect to modelling accuracy, efficiency and transparency in the context of several benchmark case studies. In particular, rule base compression is shown to be more efficient than rule based reduction for a wide range of systems but while also not compromising accuracy. Besides this, modular rule bases are shown to be more transparent than chained rule bases for a wide range of networks while also being superior in terms of accuracy.