CEUR Workshop Proceedings Vol. 1885, ISSN 1613-0073, © 2017 A. Ligęza

Rules, Causality and Constraints. Model-Based Reasoning and Structural Knowledge Discovery

Antoni Ligeza[1]

AGH University of Science and Technology in Kraków, Poland
ligeza@agh.edu.pl,
WWW home page: http://home.agh.edu.pl/ ligeza

Abstract: Data Mining techniques are widely applied to build models in the form of rules, decision tress or graphs. Some most successful techniques include algorithms for decision tree induction (with ID3, C4.5, C5.0 being the most prominent examples), frequent pattern mining (e.g. the Apriori algorithm for association rules mining) or Directed Acyclic Graphs for causal probabilistic modeling (the Bayesian Networks). In the domain of Fuzzy Sets there are approaches covering the experimental data (e.g. the Hao-Wang algorithm). Some more mathematically advanced tools incorporate Rough Sets Theory, Granular Sets, or approximation tools.

Such techniques, although useful in practice, are limited to discover the shallow knowledge only. They are based on efficient grouping techniques, relative frequency, or estimated probabilistic distributions. In general, they quite often answer the question "how does the system behave?" in terms of input-output relation, but unfortunately do not explain "why the systems behaves in a specific way" — with reference to it internal structure and components.

In contrast to widely explored popular Data Mining tools and techniques, the presentation is focused on investigating the phenomenon of causality and exploration of the paradigm of Model-Based Reasoning. An attempt is made to describe the idea of causal rules and functional dependencies on strictly logical background. The main focus is on modeling and discovering deep, causal knowledge, including the internal structure and components behavior of analyzed systems. Such a deep causal knowledge allows for different modes of Model-based Reasoning: deduction can be used to model expected system behavior, abduction can be used for analysis and diagnostic reasoning, and consistency-based reasoning can be used for structure discovery. As a tool we employ Constraint Programming. It seems that the presented approach can contribute to an interesting extension of the current Machine Learning capabilities.

Antoni Ligeza graduated from Faculty of Electrical Engineering, Automatics and Electronics (present: Faculty of Electrical Engineering, Automatics, Informatics and Electronics, EAIiE), AGH – University of Science and Technology in Cracow, Poland; received M.Sc. in electronics/automatic control in 1980. After completing Doctors Studies he received his Ph.D. degree in computer science (1983), and the habilitation (docent degree; polish Dr habilitowany) in 1994 in Computer Science/Artificial Intelligence, both from the EAIiE Faculty at AGH. In 2006 he received the professor title from the President of Poland. His main research concern Knowledge Engineering (Artificial Intelligence) including knowledge representation and inference methods, rule-based systems, automated plan generation, technical diagnostics, logics and systems science. Some most important original research results include development of backward plan generation model (1983), independent discovery of dual resolution method for automated inference (1991), the concepts of granular sets and relations (2000), granular attributive logic (2003) and diagnostic inference models in the form of logical AND/OR/NOT causal graphs (1995) and Potential Conflict Structures (1996). He was visiting professor at LAAS, Toulouse, France (1992, 1996), Universite de Nancy I, France (1994), University of Balearic Islands, Spain (1994, 1995, 2005), University of Girona, Spain (1996, 1997), and Universite de Caen, France (2004, 2005, 2007). He published (as author and co-author) more than 200 research papers, including recent monograph Logical Foundations for Rule-Based Systems", Springer, 2006. Member of IEEE Computer Society and ACM.