Editorial

Special Issue: Information Engineering Applications Based on Lattices

Guest Editor: Vassilis G. Kaburlasos

With the proliferation of computing devices, as well as of information technologies, a variety of domain-specific information processing paradigms has appeared in different application domains including signal/image processing, system modelling, machine learning, data mining, knowledge representation, pattern analysis, logic and reasoning, symbol manipulation, etc. The corresponding mathematical tools are, frequently, different also due to the need to cope with disparate types of data including, in particular, matrices of real numbers, (cumulative) functions, sets/partitions, information granules, logic values, data structures/relations, strings of symbols, etc. A unification of the aforementioned tools is expected to result in a fruitful cross-fertilization of technologies. However, what is currently missing is an "enabling" mathematical framework.

It turns out that various types of data, including the aforementioned ones, are lattice (partially)-ordered. Hence, lattice theory (LT) emerges as such an "enabling" mathematical framework for sound analysis and design involving numeric and/or nonnumeric data. Note that mathematical lattices were introduced in the first half of the nineteenth century as a spin off of work on formalizing propositional logic. During the next one hundred years following the mid-nineteenth century, LT was compiled (Birkhoff, 1967). Currently, in addition to being a branch of applied mathematics, LT emerges as a formal framework in information engineering as explained next.

There are at least four (mostly isolated from each another) research communities that "heavily" employ LT in different information processing domains. These communities are: (a) Logic and Reasoning for automated decision-making (Xu, Ruan, Qin, Liu, 2003), (b) Mathematical Morphology for signal/image processing (Serra, 1982), (c) Formal Concept Analysis for knowledge-representation and information-retrieval (Ganter, Wille, 1999) and (d) Soft Computing for clustering, classification, and regression (Kaburlasos, 2006).

Despite creative interactions within each of these communities, there is little interaction with one another. In conclusion, practitioners of LT typically develop their own tools/practices without being aware of valuable contributions by colleagues in other communities. Hence, potentially useful work might be ignored or duplicated. Sometimes, a conflicting terminology is proposed.

In response, there have been initiatives towards a creative interaction/integration of LT-based research as follows. First, a book edited by Kaburlasos, Ritter (2007) has pursued an interaction among lattice-based neural computation, mathematical morphology, machine learning, logic and inference. Second, a booklet edited by Kaburlasos, Priss, Graña (2008) has pursued interaction among lattice-based conceptual structures, granular system modeling, lattice computing, and fuzzy implications. Third, an international conference special session organized by

Kaburlasos, Sossa, Joslyn (2010) has pursued further interaction among all aforementioned four research communities that actively employ LT.

In the meantime, the term Lattice Computing (LC) was introduced by Graña (2009) to denote data processing in a mathematical lattice. Note that based on meaningful (lattice-ordered) knowledge-representations, including information granules, a novelty of LC is its capacity to compute with *semantics*. Hence, LC can be instrumental in the mathematics of uncertainty, granular computing and, ultimately, in computing with words. Furthermore, here we set forth the following conjecture: Lattice (partial)-order, as a special binary relation equipped with sound mathematical tools, can be instrumental for the study of other binary relations.

Statistical evidence strongly suggests that the work of researchers, who employ LT, is "diversified" in the sense that it, often, involves several different application domains. The aforementioned diversification may be explained in view of the unifying character of LT as it was pointed out originally in mathematics (Birkhoff, 1967) and, later, demonstrated in soft computing (Kaburlasos, 2006). Hence, in addition to its potential in general system studies, especially promising applications of LT are in inherently multidisciplinary domains such as human-computer-interaction (HCI), human-centered-computing, affective computing, cognitive robotics, etc.

This Special Issue is yet another initiative for bringing forward novel ideas and competitive research results of multidisciplinary character. We hope that the body of work presented here be a critical mass for further developments in the field.

A total of 46 high quality papers were submitted to this special issue by authors from 19 different countries around the world. The review process has followed the same standard as regular submissions to the Information Sciences journal. Due to the limited space available in this special issue we include only 16 papers. One of our primary concerns was to demonstrate the wide scope of lattice applications in information engineering. In most papers here, the employment of lattices is critical. Our focus was on applications of practical significance. Nevertheless, some mathematically oriented papers with a promising potential in practical applications are also included. In addition, we include a review paper with the intention to identify and accelerate vitally relevant and emerging trends. Next, we describe succinctly the articles in this Special Issue.

1) R. Belohlavek, E. Sigmund and J. Zacpal present a new approach to evaluation of questionnaires and its application to International Physical Activity Questionnaire (IPAQ) data describing physical activity of a population.
2) G.X. Ritter and G. Urcid determine endmembers in hyperspectral images, subject to linear mixing, from the scaled column vectors of two lattice autoassociative memories.
3) J. Konecny describes isotone fuzzy Galois connections and concept lattices parameterized by particular unary operators, namely truth-stressing and truth-depressing hedges.
4) Xinde Li, J. Dezert, F. Smarandache and Xinhan Huang introduce a method for selecting consistent sources of evidence among all available sources; moreover, they demonstrate a practical application to robot perception.

5) Yang Xu, Jun Liu, Da Ruan and Xiaobing Li investigate resolution-based automated reasoning, within an established lattice-valued logic system, in order to handle imprecision and incomparability in decision making applications.
6) A. Kehagias studies fuzzy intervals/numbers, emphasizes that these seemingly different concepts are actually very similar and establishes some algebraic properties to introduce a new transitive inclusion measure, which can prove useful for applications.
7) V. Syrris and V. Petridis present a computational approach based on both lattice theory and predictive modular neural network towards real-time human action recognition from video streams.
8) F.J. Valverde-Albacete and C. Peláez-Moreno extend Formal Concept Analysis, first, by allowing entries for contexts in an idempotent semifield and, second, by allowing different types of multi-valued object-attribute set pairs to be considered as formal concepts.
9) M. Graña, D. Chyzhyk, M. García-Sebastián and C. Hernández demonstrate an application of the Lattice Independent Component Analysis (LICA) unsupervised scheme, that is a non-linear alternative of Independent Component Analysis (ICA), to functional Magnetic Resonance Imaging (fMRI) data analysis.
10) P. Sussner and E. Laureano Esmi present the morphological perceptron with competitive learning including its lattice-theoretical background, constructive learning algorithms, and experimental comparisons with a range of other models in applications to some well-known classification problems.
11) S. Munoz-Hernandez, V. Pablos-Ceruelo and H. Strass detail a multi-adjoint fuzzy tool over Prolog including declarative and operational semantics, syntax and implementation.
12) M. Nachtegael, P. Sussner, T. Mélange and E.E. Kerre review the role and evolution of fuzzy set theory in mathematical morphology, from tool (using the lattice [0,1]) to uncertainty model for images (using the lattice of closed subintervals of [0,1]).
13) M. Kaytoue, S.O. Kuznetsov, A. Napoli and S. Duplessis compare two lattice-based approaches for mining numerical data: one approach based on concept lattices, and an equivalent one based on a natural intersection operation on numerical intervals.
14) I. Bloch proposes handling and processing imprecise and bipolar information using mathematical morphology on lattices of fuzzy sets and bipolar fuzzy sets.
15) B. Galitsky and J.L. de la Rosa explore how concept learning techniques, where scenarios are represented as graphs, can support simulation of human behaviour in customer relationship management systems.
16) S. Nedjar, R. Cicchetti and L. Lakhal detail the computation of an emerging cube towards capturing trend reversals in multidimensional data warehouses.

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