

## Editorial

### Granular Computing

This Special Issue of the Archives of Control Sciences devoted to *Granular Computing* is a response to a rapidly growing interest of the research community in this new paradigm of information processing. In a nutshell, granular computing is geared towards representing and processing basic chunks of information – information granules. Information granules, arise through the process of aggregation of some generic information entities such as numbers using various criteria of similarity, proximity, indistinguishability or alike. What are the basic information entities is obviously context dependent and although frequently we deal with granulation of numerical entities into sets of some kind, granulation of fuzzy entities, such as words, becomes increasingly important in the context of vast electronic text resources provided by the Internet. No matter how this granulation proceeds and what fundamental technology becomes involved therein, there are several essential factors that drive all pursuits of information granulation

- A need to split the problem into a sequence of more manageable and smaller subtasks. Here granulation serves as an efficient vehicle to modularize the problem. The primary intent is to reduce an overall computing effort
- A need to comprehend the problem and provide with a better insight into its essence rather than get buried in all unnecessary details. In this sense, granulation serves as an abstraction mechanism that reduces an entire conceptual burden. As a matter of fact, by changing the “size” of the information granules, we can hide or reveal a certain amount of details one intends to deal with during a certain design phase. Also, and this is one of the fundamental benefits of granulation, the transition from detailed to granulated decision space allows conversion of NP-hard problems into problems that are solvable in polynomial time (be it with a reduced accuracy).

One may argue that information granulation is a cornerstone of human perception of the world. We do not look at individual pixels but make sense of an image by granulating it into meaningful segments. We do not rely hear individual sounds but granulate them into words and phrases. The list of examples of this nature goes on and on.

We can trace the roots of granular computing to the analog-to-digital transformation that brought about digital computers. The long-lasting tradition of computing using some specific information granules is a visible testimony that versions of granular computing are omnipresent indeed. By tradition (and the associated technology dominant at that time), we have embarked on the digital world of computing. To interact with the continuous (analog) world, we use set-based granulation (more specifically, interval-valued granulation). Although originally this was not referred to as granular computing, the investigation of trade-off between the generality of interval representation of real numbers and the accuracy of the resulting computations is the same as the one pursued in the more general setting of granular computing today.

Granular computing embraces a number of fundamental methodologies within which we cast all processing and applied facet of this paradigm. Such methodological and algorithmic frameworks involve set theory (usually manifesting in the form of interval analysis), rough sets, fuzzy sets, probability, shadowed sets, to name the most representative ones. Here we can refer to the pioneering works of Zadeh on fuzzy sets and information granulation [3-6], Pawlak's [1-2] on rough sets and Warmus' [7] on interval analysis and approximate computing. This trend has been subsequently expanded by other researchers who enlarged both depth and scope of granular computing pursuing the development of the unified computing and methodological platform.

In this issue we have gathered eight contributions that address the fundamental and applied issues encountered in granular computing. We aimed at striking a balance between the algorithmic and applied end of the spectrum as well as bringing several representative vehicles of information granulation.

The paper by Kreinovich and Alo, examines interval mathematics as a basis for granulation of numerical information. In the pursuit of accuracy of interval computations a hierarchical, multi-level granulation is introduced and discussed in the context of several case studies. A pragmatic approach of analysing systems first at the low-resolution level, to obtain an approximate solution, and then refining the analysis with higher resolution study has shown its potential on applications ranging from image processing to system control. The study by Ishibuchi and Yamamoto addresses the effect of fuzzy discretization on the classification performance of fuzzy rule-based systems. It is shown that interval discretization can be viewed as a special case of fuzzy discretization that has no overlap between the neighbouring areas. The paper shows how fuzzy rules can be constructed so that they are not affected by the sparseness of the learning data. The paper by Chien, Lin and Chen is cast in the context of data mining. It looks into the methodology for granulation of numeric data, where the additional abstract interpretation of granules may not be readily available. The proposed method considers two threshold factors, information density-similarity and information closeness, to measure the condition if two granules should be merged and construct an abstraction hierarchy of intervals. The paper by Castellano, Fanelli, and Mencar proposes an approach to derive fuzzy interpretable information granules from numerical data. In this approach, granules are first formed by means of a double-clustering technique, and then properly fuzzified so as to obtain interpretable granules, in the sense that they can be described by a collection of semantically sound linguistic labels. The experimental facet of the study concentrates on the classification problems. The study by Damiani and Khoshla deals with The *eXtensible Mark-up Language (XML)* and looks at a way of forming information granules in this setting. The introduced XML data model, called *InfoSet*, represents XML documents as *multi-sorted graphs*, including nodes belonging to a variety of types. The paper presents a technique for organizing well-formed XML information items around user provided *graph patterns*. The approach is based on a *graph granulation* technique that allows agents to extract XML data at different levels of detail, using XML graphs' edges as a hint to semantic relation between nodes.

The paper by Homenda addresses an interesting issue of information granulation in optical music recognition (OMR). The process of paper-to-computer-memory music data flow is presented from the perspective of the processes of acquiring information from plain low-level data. The discussion outlines an interpretation of this process as a metaphor of granular computing and elaborates on the main stages of data aggregation and data abstraction. The paper by Rybalov elaborates on some optimisation issues of the process of information granulation and introduces a notion of granular relevance sought as a suitable descriptor of the information granules. The way of forming information granules via clustering is discussed by Bargiela, Pedrycz, and Hirota. It is shown how the clustering helps identify and quantify anisotropy of the feature space. Subsequently, it is shown that the granulation reveals some ranking of the features in the data space.

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