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Granular computing models and methods based on the spatial granulation

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Abstract

Automatic data processing and extraction of rules from large datasets has gained considerable interest during the last years. Several approaches have been proposed, mainly based both statistical and fuzzy sets approaches. In this paper, we propose a new view to the approaches to represent the large datasets and to find rules in one. That makes use of so-called Information Granulation and Computing with Words methods. The basic Ideas and principles of Granular Computing have been studied explicitly or implicitly in many fields in isolation. With the recently renewed and fast growing interest, it is time to extract the commonality from a diversity of fields and to study systematically and formally the domain independent principles of Granular Computing in a unified model. A framework of granular computing can be improved by applying the inherited principles of Space Granulation and Computing with Shapes. In this paper, we examine a framework from new perspectives of granular computing, based on Space Granulation and Computing with Shapes for the granulated data processing and problem solving.

Keywords: granular computing; spatial granulation; intelligent system; computing with words.

1. Introduction

Human-like data perception and analysis involves the Information Granularity (IG)[1,2,3]. The consideration of granularity is motivated by the necessary for the information simplification, clarity, low cost, approximation and

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tolerance of uncertainty[2]. As an emerging field of study, Granular Computing (GrC) attempts to formally investigate and model the group of granule-oriented methods and the same information processing paradigm[4].

Ever since the introduction of the terms of IG and GrC, we have witnessed a fast development of and a rapid growing interest in the topic[1,4]. Many models and methods of granular computing have been proposed and investigated. The studies of concrete models and methods are useful for the development of a field in its early stage. It is equally important, if not more, to study a general theory that avoids constraints of a concrete model.

The basic notions and principles of granular computing, though under different names, have been appeared in fact in many related fields, such as artificial intelligence, interval computing, quantization, data compression and processing, cluster analysis, databases, and many others[5,6,7,8]. However, granular computing has not been fully explored. It is time to extract the commonality from these difference fields and to explore formally the domain principles of GrC in a graphic framework. This paper is organized as follows: section II introduces the basic ideas of Granular Computing, the next section shows the mathematic background and basic formalisms for the affine space. Section IV presents the Cartesian granules in affine space and the common model for the such granules. In section V some results in new kind of affine space measures are presented an used for the granulated data processing. Finally, we conclude with a discussion of space granulation some extensions and ideas for future work.

2. Basic ideas of Granular Computing

There are several key formal frameworks contributing to GrC and forming its mathematic content. GrC can be realized in various formal frameworks[8,9].

2.1. Set theory and interval analysis

Sets are fundamental concepts of mathematics and science[10]. Likewise, interval analysis ultimately dwells upon a concept of sets which in this case are collections of elements in the line. Multidimensional constructs are built upon Cartesian products of numeric intervals and give rise to computing with hyperboxes[4]. Conceptually, sets (intervals) are rooted in a two-valued logic with their fundamental predicate of membership. The interval analysis is a cornerstone of reliable computing which in turn is ultimately associated with digital computing in which any variable is associated with a finite accuracy (implied by the fixed number of bits used to represent numbers). Intervals offer a straightforward mechanism of abstraction; all elements lying within a certain interval become indistinguishable and therefore are treated as identical.

Here we are concerned with more complex and inherently multifaceted concepts and notions, where fuzzy sets[1] could be incorporated into the formal description and quantification of such problems yet not in so instantaneous manner[2]. All of these notions incorporate some components that could be quantified with the use of fuzzy sets yet this translation is not that completely straightforward and immediate as it happens for the category of the explicit usage of fuzzy sets.

2.2. Shadowed sets

Fuzzy sets are associated with the collections of numeric membership grades. Shadowed sets[4] are based upon fuzzy sets by forming a more general and highly synthetic view at the numeric concept of membership. Using shadowed sets, we quantify numeric membership values into three categories: complete belongingness, complete exclusion and unknown (which could be also conveniently referred to as don't know condition or a shadow). This helps us contrast these three fundamental constructs of information granules[1]. In a nutshell, shadowed sets can be regarded as a general and far more concise representation of a fuzzy set that could be of particular interest when dealing with further computing (in which case we could come up with substantial reduction of the overall processing effort). Shadowed sets arc isomorphic with a three-valued logic, and operations on shadowed sets are the same as in this logic. The underlying principle is to retain the vagueness of the arguments (shadows of the shadowed sets being used in the aggregation)[5].