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Granular Computing - A Theoretical Study

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ABSTRACT
Granular computing becomes known as an innovative multidisciplinary study and has established much attention in recent years. The framework shared multiple views and multiple levels of understanding in each view from many fields. The three components of the theory are labeled as the philosophy, methodology and the computation, the integration of the above view of granular computing as a way of structured thinking, structured problem solving and information processing and hierarchical granular structures. By using the levels of granularity, granular computing provides a systematic, natural way to analyze, understand, represent, and solve real world problems. The granular computing is a more philosophical way of thinking and a practical methodology of problem solving. This paper presents the study of basic inspiration for granulation and direct Granular computing as a structured combination of algorithmic and non-algorithmic information processing.

Keywords:- Granular computing, hierarchy, structured thinking, structured problem solving, Triarchic Theory

I. INTRODUCTION

In 1979, first time Zadeh [3], [11] declared and explains the concept of information granulation and recommended the information granulation that adapts with fuzzy set theory may offer efficient answers for different applications. In 1997, T. Y. Lin [1], [2], [6], [10] was introduced the Granular computing first time to label some new area of multi-relative studies. The basic theory of granular computing was presented as information granularity or information granulation [1], [5]. Many ideas like natural and social scientific disciplines are represented by granular computing [13].

The interrogative sentence that comes first into what is granular computing, most of researchers utilized the term granular computing without giving a complete definition and as it is not possible easy one [3] [8]. Alternatively, one relies on an agreement of the granular computing based on their working domain and their own intuition [3], [17]. So that no specific explanations may for aspects of granular computing, this may be counterproductive at the early development stage of the study [3].

The researchers of granular computing can create the problem based on hypotheses and models of computational intelligence. From that the granular computing is not come under the specific examples and methods. Thither are many positive aspects for the using of granular computing. Granular computing provides true and innate representations of giving systems. Through the multiple level hierarchy representation, one can easily get a broad understanding of a system.

The carrying out of granular computing would lead to more effective information processing schemes. Unwanted, irrelevant details are avoided by focusing on the right level of abstraction. Different hierarchy levels focus on various granularities characterized by different grain sizes. From that way the granular computing able to simplify a complex system or a complex problem.

Machine Learning (ML) is grounded in the learning form the sample information. Many arenas have been executed in this field of granular computing, among which are rough set, nearest neighbor classifier, decision tree induction, Bayesian networks, induction rules learning, neural nets, genetic algorithm etc. [12]. Dealing samples with granular computing and a classifier may take from these reconstructed data obtained accurate rate will be a comparative with learning from the raw information straight off in a higher categorization [20].

Human problem solving involves the perception, abstraction, representation and understanding of real problems [19], as well as their solutions, at various levels of granularity. The granularity is motivated to use for its practically simplified the problem, clarity, low expansive, correct approximation, and tolerance of uncertainty.

This paper is organized as follows. Section II discusses about the Basic Components of Granular Computing. Section III describes about the Triarchic Theory of Granular Computing. Section IV summarizes Basic Issues of Granular Computing. Section V focuses on Human-Inspired Granular Computing. Section VI explains the conclusion.

II. BASIC COMPONENTS OF GRANNULAR COMPUTING

On modeling aspects of granular computing, basically three components are focused and their interactions also analyzed.

A. Granules:

A granule can be identified as one of the small numeric elements that constructing a bigger unit. Jointly, the granules give a theatrical performance of the basic unit with regard to an appropriate degree of granularity [18], [19]. That's why a granule is known as a particular basic unit of a large unit or a localized perspective.

Granules are created at a particular level. They are the subjects of representation at that corresponding level. Various levels focus on different, though related, types of granules. Description and understanding a level is grounded on the properties of granules [3]. Levels are connected each other through a partial order. Granules in different levels are related to each other [7] [12].

Most significant properties of granules and granular level is their granularity. The granularity of a level represents to the entire properties of granules present in a level with respect to their size or count [3], [18]. The granularity is replicated by the size of all granules involved in corresponding level and aids us to fabricate a structure identified as a hierarchy [4]. The hierarchy is used to represent a separate partition of partially ordered granulated levels, in which each level consists of a family of interrelated and interacting granules. The hierarchy provides a number of various granular views among the whole discussion [11].

B. Level:

The granularity of a level refers to the collective properties of granules in a level with respect to their size [11]. Human being can obtain the satisfied result of a problem with limited cognition, which is avoiding the incompleteness in the deepest point of the knowledge [12]. The granularity is described by the entire size of all granules participated in level and provide us to construct a hierarchical structure called a hierarchy. The hierarchy is used to highlight a family of partially ordered granulated levels, in which each and every level consists of a family of interconnected and interacting granules [11].

Apprehension of an information processing with regard to a granular computing system involves explanations at various levels like, computational, algorithmic, and implementation [19]. The problem solved by the system is identified by the computational level. The algorithm level provides the steps to resolve the problem and the implementation level deal with the physical realization.

Interpretations of the partial order of a hierarchy are fundamentally important. The levels of structure and levels of description are more general interpretations. Some of few additional interpretations are given below [3]:

1) Levels of abstraction: Various levels of abstraction may be representing different granulated views of our own understanding of a problem with respect to real world [3].

2) Levels of reduction: As the matter of fact, how the problem has been understood and explanation of an own perspective view can be derived by shortening it to its constituents or other's view that are more basic or rudimentary.

3) Levels of control: Hierarchies and systems are connected by levels of control. The lower levels are playing as a subordinate to their higher levels [3].

4) Levels of detail: Levels of detail play a significant function in the implementation of data organizations. Normally top-down implementation is projected for a computer software system by adding more details in a footstep by step.

The levels are relatively independent with respect to some degree. The bridge principles are used to join and interact between two adjacent levels [3], [19].

C. Hierarchies:

Granules present in various levels are linked by the operations on granules and order relations [11], [19]. The ranking of levels, based on their relations and operations can be traced by the term of Hierarchy. A level is above another level if each granule in the previous level is ordered before a granule in the present level. Under the order relation each granule in the present level is ordered after a granule in the previous level. A granule in a higher level can be split up into the number of granules in a lower level, and inversely, number of granules in a lower level can be combined into single granule in a higher level. A higher level granule is used to distinguish the lower level granule by avoiding the irrelevant information [19].

D. Granular structures:

The interrelation among granules, levels and hierarchies may be represented by three sorts of structures. They are internal structure of a granule, collective structure of all granules, which means the internal structure of a granulated view or level and the overall structure of all levels [11].

Proper description, interpretation, and characterization of the granules are provided by the internal structure of a granule [19]. Collective structure of all granules is the internal structure of a granulated view of the level. The internal structure of a level is only complete when all the granules in the level are considered together. In a hierarchy concept, both the internal structure of granule and the internal structure of granulated [19] views are combined to some degree by the order relations. If there are number interpretations of the order relation in levels leads to one can derive multiple hierarchies for the particular system. Each hierarchy is explained based on a corresponding interpretation of the order relation [3].

III. TRIARCHIC THEORY OF GRANULAR COMPUTING

The philosophy of structured thinking, the methodology of structured problem solving, and the computation of structured information processing are the three perspectives of granular computing [13], [14], [20]. When a multilevel hierarchy provides a particular view, a collection of many hierarchies represents a multitier description.

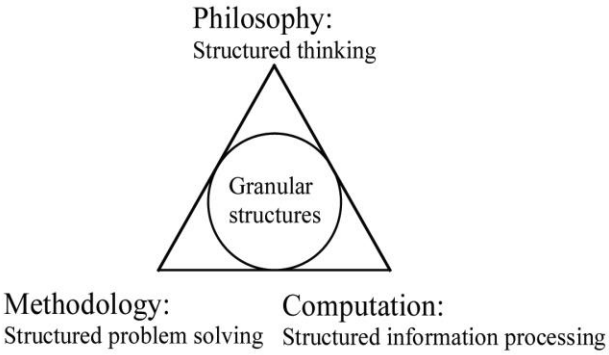

Fig. 1 The granular computing triangle

The center of the triarchic theory consists of three important views in granular computing: the philosophy of structured thinking, the methodology of structured problem solving, and the computation of structured data processing. The internal views of granular structures are characterized by multilevel and multiview. A multilevel hierarchy represents a particular view; a collection of many hierarchies represents a multiview description [14] of the granule.

Fig 1. Shows the granular computing triangle, the main components of the triarchic theory are granular structures and the three peaks of the triangle represent the philosophical, methodological and computational perspectives.

A. The Granular Computing Triangle

1) Philosophy

The granular computing proposes a worldview characterized by special sized, interacting and hierarchically organized granules. This aspect of the structures as exemplified by various levels leads to a means of structured thinking, which is applicable to many branches of natural and social scientific disciplines. The multilevel structures that are levels of abstraction, levels of understanding, levels of interpretation, levels of organization, levels of complexity, levels of processing and levels of details have been mostly used with respect to every branch of the sciences, education, history and language understanding, ecology and social sciences, computer science and systems theory, modeling human memory and programming languages [20].

Generally granular computing draws, results from two or more complementary philosophical views among the hardness of real-world problems named as, traditional reduction thinking and the recent systems thinking. Granular computing joins the analytical thinking of splitting up a whole into parts and synthetic thinking for integrating components into a whole [20] [13].

2) Methodology

As a General method of structured problem solving, the granular computing promotes systematic approaches, effective principles, and practical heuristics and strategies that have been used effectively by humans in solving real-world problems. An inner issue is the exploration of granular structures. It requires three basic tasks: constructing granular structures, functioning within a particular layer of the social system, and changing over between levels [20] [14].

Several such principles are seen here. The principle of multilevel granularity emphasizes the efficient exercise of a hierarchical construction. Agreeing to this rule, we must see multiple representations at different degrees of coarseness. The principle of multiview stresses the consideration of diversity in modeling. It asks to appear at the same problem from many angles and positions. Once granular structures are obtained, we can apply other principles to act based on such structures. For instance, the principle of focused effort calls for attention to the focal point at a special phase of problem solving; the principle of granularity conversion links the different stages in this operation. The principle of view switching allows us to exchange views and to compare different aspects. Those principles of granular computing have, in fact, are being employed extensively in different fields under different names and notes. Many rules of structured programming can be readily adopted for granular computing [20].

3) Computation

As a novel paradigm of structured information processing, the granular computing focuses on computing methods based on the granular structures. The term computing needs to be seen in its wider significance to include information processing in the abstract, in the mind and in cars. While information processing in the abstract deals with theories of computing without direct mention to their implementations, information processing in the mind and in machines represent the biological (natural) and the physical (artificial) implementations, respectively [13].

Two related basic issues of computation are representations and procedures (operations). The representation covers the formal and precise description of granules and granular structures. Procedures may be generally split into the two classes: granulation and computation with the granules. Granulation processes involve the structure of the building blocks and structures, namely, granules, levels, and hierarchies. Computation processes explore the granular structures. This requires two-way communications up and down in a hierarchy, as well as changing over between layers [14].

The three perspectives of granular computing are related and mutually defend each other. Their integration puts granular computing research on a loyal foundation. In summation, the granular computing triangle recommends a research direction towards an interdisciplinary wholeness approach. That is, researchers in different studies may investigate different perspectives of granular computing and at the same time integrate their individual results [20].

IV. BASIC ISSUES OF GRANULAR COMPUTING

In that respect are three central issues in granular computing: Granulation of the universe, description of

granules, and relationships between granules. These matters have been considered either explicitly or implicitly in various domains [16], such as data and cluster analysis, concept formation, image processing, knowledge discovery and data mining.

Computing with granules and construction of granules are the two related aspects; they are used to study about the issues of granular computing [18]. Granulation of a universe breaks the universe into small partition or creates a class containing a group of individual elements, based on knowledge and information about the universe. Elements presents in a granule are derived by similarity, indistinguishability and proximity or functionality [19].

Each concept is understood based on the two consist part called as intension and extension of the concept. The intension or comprehension of a concept contains of all attributes and properties that are valid representations for all selected objects which are belonging to the concept [18]. First the concepts are described and constructed; anyone can develop methods for computational using granules. A set of objects or entities which are providing instances of the concept is known as the extension of a concept. The relationships between concepts like intensions and extensions, such as sub-concepts, disjoint and overlap and partial sub-concepts are easy to study. The issues of granular computing are summarized below:

A. Granulation:

Granules, granulated views and hierarchies are the three basic components that are constructed by the granulation [19]. Granulation is a domain and application dependent. Unless otherwise, no one can predict some domain independent issues without the knowledge of the particular domain.

1) Granulation criteria*:* A granulation criterion gives the answer of question, why two objects are categories into the same granule

2) Granulation methods: developing an algorithm is a most important for constructing granules and granulated views efficiently with respect to the granulation criterion [18], [19]. This algorithmic aspect point out the problem of how to put two objects into the same granule.

3) Representation/description: Representation is meant by the structure of the granule. If the structure is constructed, it is necessary to name and to label granules using certain languages and describe.

B. Computing with the granules:

There are three types of structures supports the Computing and reasoning with granules [18]. They can be unified studied from semantic and algorithmic perspectives. Different methods based on the interpretation of granules and interrelationships between granules are creating the necessary of design and interpret.

1) Mappings: Mappings can be described the connections between different levels of granulations. The problem is sorting out based on the granularity of the level by each level of the hierarchy. The mapping connects various representations of the same problem at various levels in detail [19].

2) Granularity conversion: A fundamental work of granular computing is to convert the views based on the various levels of granularity. In conversion process the objects move from one level of detail to another [19], it needs to change the representation of a problem. If it is not possible, the information cannot be seen and move to view can improve the high level understanding by avoiding unnecessary details of the problem accordingly.

3) Operators: Operators are uniquely described the conversion of granularity in various levels and they may provide the basic building structures of granular computing.

4) Property preservation: Granulation insists to change the various representations for the same problem at different levels of details [18], [19]. According to these changes, the desired properties must be preserved by the granulation and its related computing methods. Then only they are meaningful.

V. HUMAN-INSPIRED GRANULAR COMPUTING

A bit of important uniqueness of human problem answering may be believed as early in approaching granular computing. First, mankind are apt to organize and categorization is important to psychological life (Pinker, 1997). The outcomes of such establishments are some types of configuration [13]. For example, hierarchical configurations seem to be a sensible alternative. For an exacting problem, we ordinarily have several stories of describing and understanding (Minsky, 2007). Third, we consider a problem at multiple levels of granularity. This permits us to focus on solving a problem at the most suitable level of granularity by ignoring unimportant and irrelevant information (Hobbs, 1985). Fourth, we can willingly switch between degrees of granularity at unusual stages of problem solving (Hobbs, 1985); it can too easily change from one description to another [14]. At the present stage, we may not be prepared to distinguish all these characteristics quantitatively. They may merely be explained to humans qualitatively through a set of principles of thumb. With the efforts of granular computing researchers, we wait for to make official some or all of them [13], [14].

At present we consider three specific problems in the study of granular computing as human-inspired problem solving.

First, granular computing focus on a special class of approaches to solving the problem; this class is differentiated by several levels of granularity [13], [14], [20]. Regarding human intelligence, Minsky (2007) points out those humans have many “Ways to think.” We can easily swap between them and make new “Ways to Think” if none of them acts upon. It is simple to prove us that humans have many approaches to resolving the problem. The usage of several layers of granularity and abstraction is simply one of them [20]. It may be real practical to study the granular computing,

not to traverse the whole scope of glide paths to solving the human problem. Thus, the restrict part of study of granular computing of human-inspired and granularity based way of problem figuring out.

Second, the granular computing has two destinations. One is to know the nature, the underlying principles and mechanisms for solving the human problem, and the other is to be relevant them in the conception and carrying out of human-inspired machines and organizations [13], [20]. They work to pass the two classes of research on granular computing, namely human-oriented studies and machine-oriented studies. These two types of fields are comparatively independent and mutually defend each other. The former concentrates on human problem solving and the latter solving the auto problem.

Tertiary, the granular computing serves for two roles. Start one to an understanding of the underlying rules of human problem solving may help more people to consciously use these rules. Once we give voice and master these principles, we become a better problem solver [20]. Second one, an understanding human problem solving is a prerequisite of building machines having the similar power. The human mind is possibly the only device that stands for the utmost stage of intelligence for solving the problem. Unlocking the mechanisms of the human brain may provide the necessary hints on designing intelligent machines [20]. The results from human-oriented studies can serve as a strong basis for machine-oriented studies. Once our understanding to solve the problem of human, we can design machines and systems based on the similar principles. Use the phrase "granular computing for machines" to denote the second aspect. In summary, granular computing is for both humans and machines.

Finally, look at granular computing again in the light of a conceptual framework by Golhooly (1989) on problem solving. According to Gilhooly, there are three angles from which one may approach the topic of problems solving [20]. The normative approaches deal with the best means for solving various types of problems; the psychological studies attempt to understand and analyze problem-solving processes in humans and other animals; computer science, or more specifically artificial intelligence, approaches focus on machine problem solving. The cognitive science integrates both human and machine problem solving from an information-processing point of view. Based on these results, Gilhooly suggests developing "a comparative cognitive science of problem solving in which the differing information processing procedures followed by human and machine may be compared and contrasted, with a view to developing general principles applicable both to natural and artificial problem solving" [13] ,[20]. It offers three perspectives on problem solving, namely, the psychological (or human) perspective, the machine perspective, and the interaction of human and machine perspectives. If the view granular computing as human-inspired problem solving, the comparative cognitive science framework is also instructive to the study of granular computing.

The communication of human and machine perspectives consider bidirectional influences. Machine analogies give to psychological approaches to human thinking, which leads to the machine-inspired information-processing approach to the study of human intelligence [13], [14], [20]. Equally, human-inspired problem solving may contribute a large deal to solving the machine problem. Whereas research on the previous is abundant, there is still a lack of study on the latter. Since solving the human problem processes are rarely identified in detail, and hence are not explained in precise terms and in a formal way, to have only rather general influences from human problem solving of machine problem solving (Gilhooly, 1989). Granular computing used to fix this break by focusing on human-inspired approaches to solving the machine problem.

VI. CONCLUSIONS

We will conduct a detailed analysis and study on granular computing may have a great impact on the design and implementation of intelligent information systems, and on real world problem solving. A view of granular computing as a human-inspired paradigm, granular computing models and triarchic theory of Granular Computing. According to the working principles of the granular computing to completely learn and understand an area of study, achieve it at multiple levels. The theory is based on granular structures and three perspectives of granular computing. Granular computing emphasizes the use of good structures representing multiview and multilevel. On the one hand, as a philosophy and general methodology, granular computing empowers everyone in problem solving; as a paradigm of structured information processing, granular computing supports human-inspired machines and systems. The triarchic theory enables us to develop granular computing as a field of study, rather than another theory or methodology.

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