Chapter 5
Decision-Making Based on Partition Order Product Space

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ABSTRACT

Granular computing focuses on structured thinking and problem solving, which solves complex problem based on granular structure. Existing studies on granular structures mainly focus on multilevel granular structure and multiview granular structure respectively, without combining multilevel granular structure and multiview granular structure. In order to describe and solve problem in a more effectively and reasonably way, we propose partition order product space by combining multilevel granular structure with multiview granular structure. To obtain a solution for problem solving in partition order product space, we propose two search algorithms: depth-first searching algorithm and breadth-first searching algorithm. From the viewpoint of granular computing, existing three-way decisions cannot effectively combine multiview and multilevel to make decisions. As the partition order product space follows the principles of multiview and multilevel, we discuss three-way decisions based on partition order product space. We propose four multiview sequential three-way decisions.

INTRODUCTION

Zadeh proposed and discussed the concept of fuzzy information granularity, which was the first time the concept of "granularity" was proposed (Zadeh, 1979). Hobbs published a paper directly titled "Granularity" (Hobbs, 1985), discussing the decomposition and merging of granules, and proposing methods and models for generating granules of different granularities. Lin T.Y. proposed "Granular Computing" during a visit in the University of California, Berkeley (Lin, 1998). Granular computing focuses on structured thinking and problem solving, which are viewed as human-inspired paradigms of computing and information processing (Bargiela & Pedrycz, 2008; Pedrycz, Skowron, & Kreinovich, 2008; Yao, 2009; Yao, 2016). It solves complex problem based on granular structure. In granular structure, a set of attributes (features) is often selected as a view to describe objects from a particular angle. In each view, objects can be further described from different levels of granularities (abstraction), and each granularity

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determines a level. Multiview and multilevel are two basic principles of granular computing (Yao, 2009; Yao, 2016). In real applications, to achieve a more comprehensive and reasonable solution in problem solving, people usually simultaneously solve a problem from both multiple views and multiple levels rather than just solving a problem from either multiple views or multiple levels (Bargiela & Pedrycz, 2008; Yao, 2009; Yao, 2016). We select medical diagnosis as an example to illustrate the importance of combining multiple views and multiple levels. In medical diagnosis, assume that a doctor needs to diagnose whether a patient has influenza or pneumonia. To obtain accurate diagnostic conclusions, patients usually have to undergo several kinds of examinations, such as routine examinations, including assessments of a patient's temperature, cough and sore throat; biochemical examinations, including routine blood tests, C-reactive protein tests and mycoplasma pneumonia tests; and imaging examinations, including X-ray, CT and MRI. Different kinds of examinations provide information about patients from different horizontal perspectives, and each kind of examination can be described as a view. In each view, with an increase in the number of examination items, information about patients becomes increasingly detailed, which constructs multiple levels of information and provides information about patients from different vertical perspectives. First, if a doctor gives the diagnosis conclusion only from a single view, such as routine examinations, there is a great possibility of misdiagnosis. Therefore, to make an accurate diagnosis, the doctor usually makes a decision from multiple views. Second, in a view such as imaging examinations, a patient does not complete all examination items at one time, after which the doctor makes a conclusion. Instead, the patient may first implement an X-ray, and then the doctor tries to make a diagnosis. If a diagnosis cannot be reached, the patient may further implement CT. Namely, in each view, doctors usually make decisions from multiple levels step by step. Last, with multiple views and multiple levels of each view, according to the real needs of the patient, he or she can flexibly implement examinations of different views and different levels. For example, the patient may first undergo examinations to assess temperature, cough and routine blood tests. If the diagnosis conclusion cannot be reached from these examination results, then the patient may undergo an X-ray examination and a C-reactive protein test. The doctor usually simultaneously combines the examination results of multiview and multilevel and flexibly chooses different views and different levels in a view to obtain more reasonable decision results.

The existing studies on granular structures mainly focus on multilevel granular structure and multiview granular structure respectively, without combining multilevel granular structure and multiview granular structure. Granular structure based on multilevel is composed of a linearly ordered family of levels, which only provides one view with multiple levels. Granular structure based on multiview provides multiple views, but each view only consists of one level. In order to understand and describe problem in a more comprehensive way, and then solve the problem more effectively and reasonably, given a universe, we take partition as the granulation method. Combining multilevel granular structure with multiview granular structure, we propose partition order product space. Partition order product space is a new granular computing model that simultaneously follows the principles of multiple views and multiple levels. Based on the partition order product space, we can solve a problem from multiple views and at multiple levels in each view. Linearly ordered multiple levels are utilized to represent a view. A partition order product space is the Cartesian product of many linearly ordered levels, which is a lattice. Each node of the lattice is a solution of problem solving, which is a family of one-level views. To obtain a solution for problem solving in partition order product space, we propose two search algorithms, which are referred to as the depth-first searching algorithm and breadth-first searching algorithm.

The theory of three-way decisions proposed by Yao (Yao, 2011; Yao, 2010) can be motivated, interpreted and implemented from the viewpoint of granular computing (Bargiela & Pedrycz, 2008; Fang,