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The movement strategy of three-way decisions based on clustering

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ABSTRACT

The movement strategy is a crucial issue of three-way decisions, which transfers objects in the unfavorable region to the favorable region. For object-based movement strategy, each object in the unfavorable region has one particular movement rule, so many objects can be successfully moved but the movement process is complex. Contrarily, for region-based movement strategy, all objects in the unfavorable region use the same movement rule, so the movement process is simple but few objects can be successfully moved. Therefore, to design a movement strategy with lower complexity and higher success movement rate, we propose a movement strategy based on clustering. First, we divide objects in the unfavorable region into several smaller clusters. Second, for each cluster, to define a reference object as its representative, we design four criteria: the highest frequency of global attribute value, the highest frequency of local attribute value, the object with maximum distance, the object with minimum distance. Third, a movement rule is developed for each cluster and the movement rules of all clusters form cluster-based movement strategy. Finally, to evaluate the effectiveness of the proposed movement strategy, we define a utility function. Experimental results demonstrate the effectiveness of the proposed methods.

1. Introduction

The TAO model of three-way decisions contains three parts [38]: trisecting, acting, and outcome, as shown in Fig. 1. The trisecting is to divide a nonempty finite set of objects (universe) into three pair-wise disjoint parts or regions. The acting is to design movement strategies to move objects among three regions, usually transfers objects in the unfavorable region to the favorable region. The outcome is to evaluate the effectiveness of the movement strategies and optimize the trisecting and acting to achieve desired results. Trisecting is the basis, acting is the means, and outcome is the ultimate goal. In recent years, researches on three-way decisions have rapidly increased. For example, three-way decisions space [12,17], three-way classification [18,21], three-way clustering [28,1,7,2,5], three-way conceptual analysis [45,15], three-way approximations [41,25], sequential three-way decisions [11,34,8], dynamic three-way decisions [36,19,35], regret three-way decisions [13,27,31,6], prospect three-way decisions [30,29]. While three-way decisions have also been widely applied in spam filtering [46,4], text processing [44], image processing [24,16], recommendation system [20,40], data mining and knowledge acquisition [11,32,33,42,39].

At present, most researches on three-way decisions focus on how to divide a universe [3,9,43], and there are relatively few studies on movement strategies. Gao and Yao [10] proposed an object-based movement strategy, which moves objects

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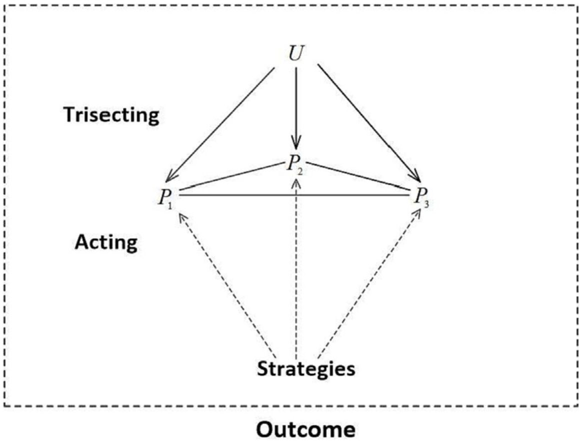

Fig. 1. TAO model of three-way decisions.

in the unfavorable region to the favorable region one by one, namely, each object in the unfavorable region has a movement rule. So according to object-based movement strategy, many objects can be successfully moved. However, as object-based movement strategy contains many movement rules, the movement process is complex and the movement time is long. Jiang and Yao [14] proposed region-based movement strategy, in which all objects in the unfavorable region use one movement rule. As region-based movement strategy contains only one movement rule, the movement process is simple and the movement time is short. However, as all objects in the unfavorable region use the same movement rule, many objects may cannot be successfully moved, namely the success movement rate is low. Therefore, to design a movement strategy with lower complexity and higher success movement rate, this paper proposes a movement strategy of three-way decisions based on clustering, called cluster-based movement strategy. The main idea is that, based on the clustering algorithm, we perform a more fine-grained division of objects in the unfavorable region and divide them into several smaller clusters. For each cluster, a movement rule is developed. The movement rules of all clusters form cluster-based movement strategy, which can use fewer movement rules and move more objects in the unfavorable region to the favorable region.

Taking medical diagnosis as an example, suppose a universe is a set of patients, the unfavorable region is a set of patients suffering from cold and the favorable region is a set of patients who do not catch cold. According to object-based movement strategy, for each patient suffering from cold, the doctor will make a specific treatment plan, namely a movement rule. Then there are many movement rules and many patients could be cured but the treatment process is complex. However, according to region-based movement strategy, for all patients suffering from cold, the doctor will make a unified treatment plan, that is, there is only one movement rule. So the treatment process is simple. But as different patients may have different symptoms and cannot be cured by one treatment plan, then many patients may could not be cured. According to cluster-based movement strategy, the doctor may divide patients in the unfavorable region into two clusters in terms of their fever state. Then the doctor will make a treatment plan for patients with fever, and make another treatment plan for patients without fever. In this situation, the treatment process is still simple, but more patients may could be cured.

To evaluate the effectiveness of the movement strategy, Gao and Yao [10] defined the costs and benefits based on the object-based movement strategy. However, this method does not consider the relationship between costs and benefits. Therefore, Jiang and Yao [14] proposed a utility function of the movement strategy by combining costs and benefits based on region-based movement strategy. However, this method assumes that all objects in the unfavorable region move to the favorable region with the same costs and benefits, which does not consider the differences between objects. Therefore, on these bases, we propose a new utility function to evaluate the effectiveness of cluster-based movement strategy by combining costs and benefits generated by different clusters.

In summary, the main contributions of this paper are concluded as follows. To design a movement strategy with lower complexity and higher success movement rate, this paper proposes a movement strategy of three-way decisions based on clustering. First, we use the clustering algorithm to divide objects in the unfavorable region into several smaller clusters. Second, for each cluster, a reference object is defined as its representative. To define the reference object of each cluster, we design four criteria: the highest frequency of global attribute value (HFGAV), the highest frequency of local attribute valve (HFLAV), the object with maximum distance (OMAXD), and the object with minimum distance (OMIND). Third, a movement rule is developed according to the reference object of each cluster and the movement rules of all clusters form cluster-based movement strategy. Finally, a new utility function is proposed to evaluate the effectiveness of cluster-based movement strategy. Experimental results demonstrate the effectiveness of the method proposed in this paper.

The rest of this paper is organized as follows. Section 2 reviews some basic concepts of the TAO model of three-way decisions. Section 3 proposes cluster-based movement strategy and defines a new utility function. Section 4 gives an example to