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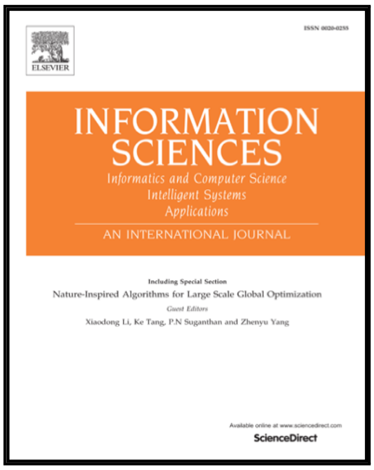

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Knowledge Distance Measure in Multigranulation Spaces of Fuzzy Equivalence Relations

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Abstract

Hierarchical quotient space structure (HQSS), which is a typical representation of multigranulation spaces, serves as the essential description tool of fuzzy equivalence relations. However, current studies on HQSS have three main limitations: (i) the inability to reflect the relationship between any two quotient spaces in an HQSS, (ii) classification isomorphism cannot characterize the degree of subdivision that exists in an HQSS with changing granularities, and (iii) the difficulty in characterizing the difference between two HQSSs that are classification isomorphic. In this paper, we address these issues from the perspective of knowledge distance. First, we propose a partition-based knowledge distance based on the Earth Mover's Distance (EMD), and we prove that our knowledge distance is equivalent to the binary granule-based knowledge distance (BGKD) but is more intuitive than the BGKD. Then, by studying the hierarchy of HQSS, we conclude that the granularity difference between any two quotient spaces in an HQSS is equal to the knowledge distance between them. In the view of knowledge distance, the concepts of classification isomorphism and subdivision isomorphism are defined and discussed. Finally, we define the concept of the knowledge difference sequence pair, which not only discriminates whether two fuzzy equivalence relations are isomorphic, but also characterizes the difference between any two HQSSs with respect to them. Theoretical analysis shows that our work is valuable for advancing the application of the hierarchy granular computing theory.

Keywords: knowledge distance; hierarchical quotient space structure; fuzzy equivalence relation; Earth Mover's Distance

1. Introduction

In the field of computational intelligence, granular computing (GrC) is a new methodology for simulating human cognitive mechanisms, including learning, thinking, reasoning, and solving complicated problems [8, 27, 28, 29, 44, 46, 50, 68]. GrC is regarded as an umbrella encompassing theories, methodologies, techniques, and tools [52]. It is a theory for using "granules" effectively to build an efficient computational model for problem solving, especially when the problem is uncertain and complex [51]. There are three main GrC models: fuzzy sets [54],

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