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Measures for evaluating the decision performance of a decision table in rough set theory

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Abstract

As two classical measures, approximation accuracy and consistency degree can be employed to evaluate the decision performance of a decision table. However, these two measures cannot give elaborate depictions of the certainty and consistency of a decision table when their values are equal to zero. To overcome this shortcoming, we first classify decision tables in rough set theory into three types according to their consistency and introduce three new measures for evaluating the decision performance of a decision-rule set extracted from a decision table. We then analyze how each of these three measures depends on the condition granulation and decision granulation of each of the three types of decision tables. Experimental analyses on three practical data sets show that the three new measures appear to be well suited for evaluating the decision performance of a decision-rule set and are much better than the two classical measures.

Keywords: Rough set theory; Decision table; Knowledge granulation; Decision evaluation

1. Introduction

Recently, rough set theory developed by Pawlak [17] has become a popular mathematical framework for pattern recognition, image processing, feature selection, neuro computing, conflict analysis, decision support, data mining and knowledge discovery process from large data sets [1,16,20–23]. As applications of rough set theory in decision problems, a number of reduct techniques have been proposed in the last 20 years for information systems and decision tables [2,3,8,9,13–15,18,19,27,30–33,36,37]. As follows, for our further development, we briefly review some of these techniques. β-Reduct proposed by Ziarko [37] provides a kind of

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attribute-reduction methods in the variable precision rough set model. α-Reduct and α-relative reduct that allow the occurrence of additional inconsistency were proposed in [15] for information systems and decision tables, respectively. An attribute-reduction method that preserves the class membership distribution of all objects in information systems was proposed by Slezak [30,31]. Five kinds of attribute reducts and their relationships in inconsistent systems were investigated by Kryszkiewicz [7], Li [8] and Mi [14], respectively. By eliminating some rigorous conditions required by the distribution reduct, a maximum distribution reduct was introduced by Mi [14]. Unlike the possible reduct in [14], the maximum distribution reduct can derive decision rules that are compatible with the original system.

A set of decision rules can be generated from a decision table by adopting any kind of reduction method mentioned above [6,29,35]. In recent years, how to evaluate the decision performance of a decision rule has become a very important issue in rough set theory. In [3], based on information entropy, Düntsch suggested some uncertainty measures of a decision rule and proposed three criteria for model selection. Moreover, several other measures such as certainty measure and support measure are often used to evaluate a decision rule [5,10,33]. However, all of these measures are only defined for a single decision rule and are not suitable for measuring the decision performance of a rule set. There are two more kinds of measures in the literature [17,19], which are approximation accuracy for decision classification and consistency degree for a decision table. Although these two measures, in some sense, could be regarded as measures for evaluating the decision performance of all decision rules generated from a decision table, they have some limitations. For instance, the certainty and consistency of a rule set could not be well characterized by the approximation accuracy and consistency degree when their values reaches zero. As we know, when the approximation accuracy or consistency degree is equal to zero, it is only implied that there is no decision rule with the certainty of one in the decision table. This shows that the approximation accuracy and consistency degree of a decision table cannot give elaborate depictions of the certainty and consistency for a rule set. To overcome the shortcomings of the existing measures, this paper aims to find some measures for evaluating the decision performance of a set of decision rules. Three new measures are proposed for this objective, which are certainty measure (α), consistency measure (β), and support measure (γ).

The rest of this paper is organized as follows. Some preliminary concepts such as indiscernibility relation, partition, partial relation of knowledge and decision tables are briefly recalled in Section 2. In Section 3, some new concepts and two lemmas for further developments are introduced, which show how to classify decision tables into three types. In Section 4, through some examples, the limitations of the two classical measures are revealed. In Section 5, three new measures (α, β and γ) are introduced for evaluating the decision performance of a set of rules, it is analyzed how each of these three measures depends on the condition granulation and decision granulation of each of the three types of decision tables, and experimental analyses of each of the three measures are performed on three practical data sets. Section 6 concludes this paper with some remarks and discussions.

2. Some basic concepts

In this section, we review some basic concepts such as indiscernibility relation, partition, partial relation of knowledge and decision tables.

An information system (sometimes called a data table, an attribute-value system, a knowledge representation system, etc.), as a basic concept in rough set theory, provides a convenient framework for the representation of objects in terms of their attribute values. An information system S is a pair (U,A), where U is a non-empty, finite set of objects and is called the universe and A is a non-empty, finite set of attributes. For each $a \in A$, a mapping a: $U \to V_a$ is determined by a given decision table, where V_a is the domain of a.

Each non-empty subset $B \subseteq A$ determines an indiscernibility relation in the following way:

$$R_B = \{(x,y) \in U \times U \mid a(x) = a(y), \forall a \in B\}.$$

The relation R_B partitions U into some equivalence classes given by

$$U/R_B = \{[x]_B | x \in U\}, \quad \text{just } U/B,$$

where $[x]_B$ denotes the equivalence class determined by x with respect to B, i.e.,

$$[x]_B = \{y \in U | (x,y) \in R_B\}.$$