Variable Precision Bayesian Rough Set Model and Its Application to *Kansei* Engineering

Tatsuo Nishino, Mitsuo Nagamachi, and Hideo Tanaka

Department of *Kansei* Information
Faculty of Human and Social Environments
Hiroshima International University
555-36 Kurose, Higashihiroshima, Hiroshima 724-0695, Japan
{t-nishi, m-nagama, h-tanaka}@he.hirokoku-u.ac.jp

Abstract. This paper proposes a rough set method to extract decision rules from human evaluation data with much ambiguity such as sense and feeling. To handle totally ambiguous and probabilistic human evaluation data, we propose an extended decision table and a probabilistic set approximation based on a new definition of information gain. Furthermore, for our application, we propose a two-stage method to extract probabilistic *if-then* rules simply using decision functions of approximate regions. Finally, we implemented the computer program of our proposed rough set method and applied it to *Kansei* Engineering of coffee taste design and examined the effectiveness of the proposed method. The result shows that our proposed rough set method is definitely applicable to human evaluation data.

Keywords: Variable precision Bayesian rough set model, ambiguity, extraction of decision rules, human evaluation data, *Kansei* Engineering, rough sets.

1 Introduction

The original rough sets approach is restricted to the case where there exist fully correct and certain classifications derived from a decision table. Unfortunately, many cases exist where there is no lower approximation of a classification. Furthermore, if there are only very few elements in a lower approximation of some decision set, the *if-then* rules extracted from these few elements might be unreliable. Thus, it is necessary to handle a huge decision table. Consequently, the combination of rough sets approaches and probability theory can be found in many research papers [15,17,18,19,20,21,23,24,25].

On the other hand, we have applied rough set methods to *Kansei* Engineering (KE) problems [8,9,10]. Kansei Engineering is defined as the 'technology to translate human needs to product elements'[5]. Its aim is to develop customer-oriented products by using relational rules embodying design attributes of products and human evaluation data such as sensory perceptions and feelings. However, these human-product relational rules are seldom used by design experts, since their structure is very complicated. Recently, it has been shown that

J.F. Peters and A. Skowron (Eds.): Transactions on Rough Sets V, LNCS 4100, pp. 190–206, 2006.
© Springer-Verlag Berlin Heidelberg 2006

rough set approaches are very effective to extract human decision rules in KE [4,5]. However, since human evaluation data involve considerable ambiguity of the decision classes, it has been very difficult to derive effective decision rules from such human evaluation data. If we consider the properties of the human evaluation data such as ambiguity and non-linearity, we have to construct a rough set method that can treat the case where there is no lower approximation of a classification, and the case where the decision classes embody with considerable ambiguity. In such situations, we directed our attention to the variable precision rough set model (VPRS)[23], Bayesian rough set model (BRS)[18,19,20] and variable precision Bayesian rough set model (VPBRS)[17] because these models are much suitable for dealing with practical human evaluation data involving ambiguity or inconsistency.

Accordingly, in this paper, we propose a modified VPBRS suitable for analyzing human evaluation data with much ambiguity[11,12]. We defined a new information gain relative to equivalent classes suitable for handling totally ambiguous and probabilistic properties of human evaluation data. Moreover, for our application, we propose a two-stage method to extract probabilistic decision rules simply from probabilistic decision tables using decision functions of approximated classes. Next, we have designed and implemented a computer program for our rough set method, and applied the proposed rough set method to real life coffee taste design in a coffee company. Its aim is to discover effective decision rules and to develop coffee manufacturing conditions to produce a new coffee taste fitted to customers based on the extracted decision rules[13]. The results show that our proposed rough set method is more applicable to human evaluation data in KE, and it extracts 'interesting' decision rules to develop new products fitted to human sense or feeling.

The rest of the paper is organized as follows. In Section 2, Kansei Engineering and its relation with rough set is described in viewpoints of practical applications of rough sets. Preliminaries and notations to describe an extended decision table for human evaluation data are introduced in Section 3. In Section 4, concepts of information gain and probabilistic approximations to properly handle human evaluation data are introduced. In Section 5, for our applications, we present a two-stage method to simply extract probabilistic decision rules using decision functions from an approximated decision table. We show an application of our rough set method to practices of Kansei Engineering in Section 6. Finally, Section 7 presents conclusions and our future work.

2 Rough Sets and *Kansei* Engineering

The trend of a new product development emphasizes consumer orientation, namely, consumer needs and feeling are recognized as very important and invaluable in a product development for manufacturers. Kansei engineering was founded by Nagamachi, M., one of the authors, at Hiroshima University around 30 years ago [5,6,7] and it aims to implement customers' feelings and needs in new product function and design. The term 'kansei' is a Japanese adjective, which