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A framework for attribute selection in marketing using rough computing and formal concept analysis

D.P. Acharjya [a,*], **T.K. Das** [b]

[a] *School of Computer Science and Engineering, VIT University, Vellore, Tamil Nadu, India*
[b] *School of Information Technology and Engineering, VIT University, Vellore, Tamil Nadu, India*

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Abstract Marketing management employs various tools and techniques, including market research, to perform accurate marketing analysis. Information and communication technology provided a new dimension in marketing research to maximise the revenues and profits of the firm by identifying the chief attributes affecting decisions. In this paper, we present a hybrid approach for attribute selection in marketing based on rough computing and formal concept analysis. Our approach is aimed at handling an information system that contains numerical attribute values that are "almost similar" instead of "exact similar". To handle such an information system we use two processes—pre-process and post-process. In pre-process, we use rough set on intuitionistic fuzzy approximation space with ordering rules to find knowledge and associations, whereas in post-process we use formal concept analysis to identify the chief attributes affecting decisions.
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Introduction

Marketing management is a business discipline that focusses on marketing techniques, management of a firm's marketing resources and activities. Rapid globalisation has compelled firms to market their products beyond their home country. Therefore, it is highly challenging for managers to influence the level, timing, and composition of customer demand; the size of the business; corporate culture; and industry context. To create an effective cost efficient marketing management strategy, firms must possess a detailed, objective understanding of their own business and the market in which they operate (Clancy & Krieg, 2000; Joshi, 2005; Kotler & Keller, 2006). With the introduction of information and communication technology, the buyer today is exposed to a veritable flood of information. These sources provide information about new products and services, improved versions of existing products, new uses of existing products and the like. Therefore, attribute selection in marketing is a challenging issue today. To this end, introduction of computers

* Corresponding author.
E-mail address: dpacharjya@gmail.com (D.P. Acharjya).
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and information technology has brought about a drastic change in the recent past. Also, the use of information at the right time helps gain better knowledge in real life, and leads to knowledge mining. Although knowledge mining from databases is, increasingly, becoming important, the knowledge discovered is not always useful to users. This is because the discovered knowledge does not necessarily fit a user's interest, and may be redundant or inconsistent with a priori knowledge. Therefore, the real challenge lies in converting voluminous marketing data into knowledge, and to use this knowledge to make informed sales output appropriately. Though present-day technologies help in obtaining decisions by creating huge databases, most of the information may not be relevant. So attribute reduction becomes an important factor in handling large databases by eliminating superfluous data to enable decision making in an effective manner. Researchers have proposed many methods to mine knowledge from the voluminous data but most of the tools to mine knowledge are traditional and are crisp, deterministic and precise in character. Real life situations are quite the opposite of this. For a complete description of a real system, often one would require far more detailed data than a human being could ever recognise and simultaneously, process and understand. This leads to the extension of the concept of crisp sets, so as to model imprecise data that can enhance their modelling power. At the other end, researchers generally make statistical inferences on the existing data. This tendency gets accentuated by increased interest in making efficient use of organisational data through data mining and data warehousing (Beynon, Curry, & Morgan, 2001). Therefore, there are enough grounds for consideration of some of the newer techniques which have developed in the recent past.

The earliest of the new approaches is the notion of fuzzy sets by Zadeh (1965) that captures impreciseness in information. Since the initiation of fuzzy set theory, there have been suggestions for non classical and higher order fuzzy sets for different purposes. Keeping in view these suggestions, the different theories developed are "twofold fuzzy sets" by Dubosis and Prade (1987); "L-fuzzy set" by Goguen (1967); "toll sets" by Dubois and Prade (1993) and "intuitionistic fuzzy sets" by Atanasov (1986). However, the major difficulties lie in the determination of membership values. In general, these are situation dependent, and not so significant in dealing with dissimilar types of problems. Even for a particular situation, due to lack of information, as also possibly due to the vagueness of the information, the membership values cannot always be determined.

On the other hand, rough sets of Pawlak (1982) capture indiscernibility among objects to model imperfect knowledge. Pawlak and Skowron (2007a, 2007b, 2007c) is an alternative technique for extracting rules from the data sets. The basic definition of rough sets depends upon the notion of equivalence relations defined over a universe. A rough set, with respect to an equivalence relation, is defined through a pair of crisp sets, called the lower and upper approximations of the set. However, equivalence relations are relatively rare in practice. So, efforts have been made to make the relations less significant by removing one or more of the three requirements of an equivalence relation. The first such attempt is the study of rough sets on fuzzy approximation spaces (De, 1999) that depend upon the concept of fuzzy proximity relation. The above concept is extended to the setting of rough sets on intuitionistic fuzzy approximation space by Tripathy (2006). Its properties, applications and comparison with rough sets on fuzzy approximation space are further researched by Acharjya (2013).

As a data mining tool, rough set theory helps in obtaining decision rules about the problem. Mahapatra, Sreekumar, and Mahapatra (2010) presented an application of rough sets as a methodology for rule derivation. But, the objective of the research work, attribute selection in marketing, is missing and it has some limitations. In order to overcome the limitation, we propose an integrated model that combines rough sets on intuitionistic fuzzy approximation space with ordering relations and formal concept analysis. The motivation behind this study is that the two theories aim at different goals and summarise different types of knowledge. Rough computing is used for prediction whereas formal concept analysis is used for description. Therefore, the combination of both leads to a better model. In the integrated model, we use two processes—pre-process and post-process—to mine suitable rules and to explore the relationship between the attributes. In pre-process we use rough set on intuitionistic fuzzy approximation space and ordering rules to mine suitable rules, whereas in post-process we use formal concept analysis to better explore knowledge and the most important characteristics affecting decision making.

For completeness, the remainder of the paper is organised as follows: the second section presents the foundations of rough computing. In the third section we discuss order information table, followed by the basic idea of formal concept analysis in the fourth section. The proposed model for attribute selection is presented in the fifth section. In the sixth section, an empirical study on attribute selection in marketing is presented. The paper is concluded in the seventh section.

Foundations of rough computing

In this age of the internet, a huge repository of data is available across various domains. Therefore, it is very hard to extract useful information from the voluminous data available in the universe. So, information retrieval and knowledge representation have emerged as one of the more popular areas of recent research. Information retrieval and acquisition of knowledge are important components of an information system. But the real challenge lies in converting voluminous data into knowledge and to use this knowledge to make proper decisions. In order to transform the processed data into useful information and knowledge, there is a need for new techniques and tools. Rough set theory developed by Pawlak (1982), used to process uncertain and incomplete information, is a tool to address the above mentioned problem. One of its strengths is the attribute dependencies, and their significance among inconsistent data. At the same time, it does not need any preliminary or additional information about the data. Therefore, it classifies imprecise, uncertain or incomplete information expressed, in terms of data acquired from experience.

Rough sets

In this section we recall the definitions of basic rough set theory developed by Pawlak (1991). Let U be a finite nonempty

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