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ROUGH SET APPROACH TO CREATE ACTIONABLE KNOWLEDGE WITHIN THE ORGANIZATION

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ABSTRACT

This paper presents an environment to support the development of actionable knowledge (knowledge that is used to create value) within the classic management systems. In order to successfully assist an organization in creating new actionable knowledge for a management consultant must be aware of a knowledge dimension called Coalescent knowledge. The process for creating actionable knowledge in this dimension is a dialogue process. For example, product development is guided by several expert knowledge including critical reflective practice which are dynamic, derived from experience and are often nonlinear. A new inductive learning intelligent technique called Rough set theory, which is to be used along with coalescent knowledge, is proposed. The induced rules are intended to be the supportive knowledge for guiding the content flow planning. They can be used as decision-support rules to achieve the objectives of the plan. The framework of the classic management has been discussed and is modified using the Rough set theory method. The proposed method has been explained via an algorithm and a running example.

Keywords: *Actionable Knowledge, Coalescent knowledge, Rough Set,Critical reflective process.*

1. INTRODUCTION

For a management consultant to successfully assist an organization in creating new actionable knowledge (knowledge that is used to create value), the consultant must be aware of a new knowledge dimension called Coalescent knowledge [1]. Knowledge in the Coalescent dimension has the following attributes:

- Created via a dialogue process involving a group of experts
- The knowledge is visible, expressible, shared and virtual
- Can be private or public knowledge
- Can be used to create a sustainable competitive advantage
- Facilitates the opportunity for a group of experts to act as if they have one mind (decided by rough set) to accomplish organizational objectives
- Scalable from two to many experts.

Morgan et al [1] updated the knowledge creation theory documented by Nonaka and Takeuchi, [2] and is expressed in Table 1:

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TABLE 1 : CHANGES TO THE NONAKA & TAKEUCHI (NK) KNOWLEDGE CREATION THEORY

Process/Mode	NK Knowledge Transition Form	New Knowledge Transition Form
Socialization	Tacit-to-Tacit	Tacit to Coalescent
Externalization	Tacit to Explicit	Coalescent to Explicit
Combination	Explicit to Explicit	Explicit to Coalescent
Internalization	Explicit to Tacit	Coalescent to Tacit

In the context of classic management system to create actionable knowledge could be incomplete or inconsistent, Rough Set Theory is used as a major tool to deal with such situation.

This paper is organized as follows. Section 1 gives the introduction about new actionable knowledge. Section 2 reviews main concepts of rough set theory through a simple example within the framework of classic management system. Section 3 presents the proposed framework of an intelligent learning system based on Rough Set Theory with the detailed discussion via a running example given in Section 4. Section 5 concludes the paper.

2. PRELIMINARIES

2.1 ROUGH SET THEORY

The concept of rough sets has been introduced by Zdzislaw Pawlak in the early 1980's as a new concept of set used in many application and research. The Rough Set theory is an important part of soft computing. The methodology is concerned with the classificatory analysis of imprecise, uncertain or incomplete information or knowledge expressed in terms of data acquired from experience. It is rather formalized through the simple concepts of lower and upper approximation, which are in turn defined on the basis of set. Given the input data, the rough set-based system generates a list of certain and possible rules[3].

An intelligent system to extract knowledge from database has been developed using features of both the rough set and fuzzy set theory[4]. The transition of data mining for non-actionable to action ability through domain related social intelligence are well discussed[5]. New data mining approach using the ideas of Domain Driven Data Mining (DDDM) has been well discussed[6]. A new inductive learning intelligent technique called Rough set theory, which is to be used along with coalescent knowledge is proposed.

The input data is a decision table comprising of conditional attributes, or conditions for short, and a decision attribute. Table 2 gives an example of a decision table containing information of eight Experts. There are three conditions: c1, c2, and c3. Condition c1 is the number of new ideas given by the experts in the Classic Management System to access the actionable knowledge, c2 is the first pretest score of each expert, and c3 is the second pretest score (the scores are intervals of numeric values). The level attribute (either basic or advanced) is a decision on the Experts performance levels. Conditions together with decision attribute form an information system.

TABLE 2: A DECISION TABLE CLASSIFYING EXPERTS PERFORMANCE EITHER AS BASIC OR ADVANCED LEVEL.

Object Member's or Expert's	*Conditions (critical reflection practice)*			*Decision* Level
	Ideas (c1)	score1 (c2)	score2 (c3)	
E1	15	0-20	0-20	Basic
E2	15	0-20	21-40	Basic
E3	20	0-20	41-60	Basic
E4	20	0-20	41-60	Basic
E5	15	0-20	81-100	Advanced
E6	15	41-60	41-60	Advanced
E7	15	21-40	61-80	Advanced
E8	20	21-40	21-40	Advanced

A decision table is a representation of real-world data. Each row represents one object. Rough Set Theory is based on the formation of *equivalence relations* [7] within the given data. Equivalence relations, also called *indiscernibility relations*, partition data in a decision table into groups of similar objects based on the values of some attributes. From the data sample in Table 1,the following is the equivalence relations partitioned with a condition (such as c1) or a combination of conditions (such as c1 and c2 and c3).

I(c1) = { {E1, E2, E5, E6, E7}, {E3, E4, E8}}
I(c2) = { {E1, E2, E3, E4, E5}, {E6}, {E7, E8}}
I(c3) = { {E1}, {E2, E8}, {E3, E4, E6}, {E5}, {E7}}
I(c1,c2) = { {E1, E2, E5}, {E3, E4}, {E6}, {E7}, {E8}}
I(c1,c3) = { {E1}, {E2}, {E3, E4}, {E5}, {E6}, {E7}, {E8}}
I(c2,c3) = { {E1}, {E2}, {E3, E4}, {E5}, {E6}, {E7}, {E8}}
I(c1,c2,c3) = { {E1}, {E2}, {E3, E4}, {E5}, {E6}, {E7}, {E8}}

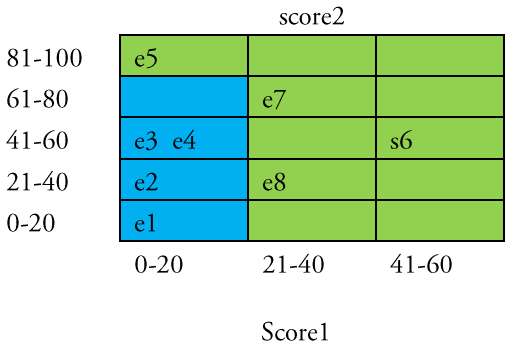
The question often arises is whether one can remove some conditional attributes and still preserve the same equivalence relations. This question leads to the notion of reduct. A set of conditions P is a *reduct* of set of conditions Q if P contains less conditional attributes than Q and the equivalence relations defined by P and Q are the same. As in the above example, I(c1,c2,c3) is a set of expert groups partitioned by considering all conditional attributes. It is thus the complete partitioning. We can notice that I(c1,c3) and I(c2,c3) yield the same group of experts as I(c1,c2,c3). Therefore, I(c1,c3) and I(c2,c3) are two possible reducts according to this particular example. The intersection of all reducts produces *core attribute*. Obviously, c3 (or score2) is a core attribute. Suppose we are given additional information of the ninth expert with exactly the same attribute values as the eighth expert except that their performance levels are different. It is such conflicting cases that inspire the rough set concept. Given the two decision sets of advanced/basic level, the uncertain cases such as E8 and E9 (as shown in Table 3) can be approximated their membership by means of lower and upper approximation [7]. The *lower approximation* of X is the set of all objects that are certainly belong to X. The *upper approximation* of X is the set of all objects that definitely do not belong to X. The area between these two sets is called *boundary region* of X. It is the set of all objects that cannot be classified as not belonging to X. If the boundary region is empty, it is a *crisp* (precise) set; otherwise, the set is *rough*. The set of advanced-level experts is given in Table 3(a) is a crisp set, whereas it is a rough set in Table 3 (b).

2.2 UPDATED KNOWLEDGE CREATION PROCESS

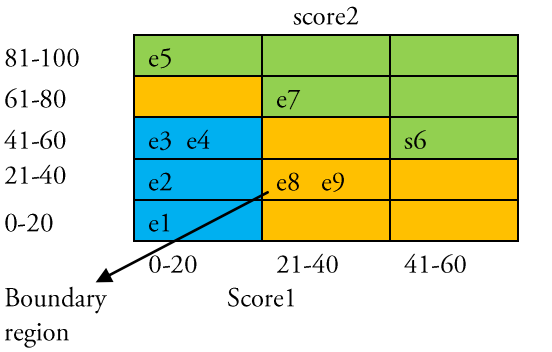
According to Morgan et al, the first process in creating knowledge is socialization. In this process, an individual shares his or her tacit knowledge with another individual or a group via some form of dialogue and/or observation [1], [2], In any dialogue and/or observation, each individual brings his or her tacit knowledge and references/links to explicit knowledge. For this analysis, it is assumed that the exchange of knowledge will be via dialogue. During the dialogue process, the first individual tries to define his/her tacit knowledge for the second person(s). This process requires the use of fields of interaction. The second person(s) then links their knowledge base to the knowledge being communicated. This is a repetitive action until the first and second person(s) agree on a common set of constructs, which define the knowledge being communicated. The process has now created a shared virtual knowledge, which only exists between the individuals involved in the dialogue. This knowledge is shared and not codified, so it does not fall within the definition of tacit or explicit knowledge.

TABLE 3. AN EXAMPLE OF (A) A CRISP SET VERSUS (B) A ROUGH SET.

	score1	score2	level
e1	0-20	0-20	basic
e2	0-20	21-40	basic
e3	0-20	41-60	basic
e4	0-20	41-60	basic
e5	0-20	81-100	advanced
e6	41-60	41-60	advanced
e7	21-40	61-80	advanced
e8	21-40	21-40	advanced



	score1	score2	level
e1	0-20	0-20	basic
e2	0-20	21-40	basic
e3	0-20	41-60	basic
e4	0-20	41-60	basic
e5	0-20	81-100	advanced
e6	41-60	41-60	advanced
e7	21-40	61-80	advanced
e8	21-40	21-40	advanced
e9	21-40	21-40	basic



The consultant can use the knowledge creation process flow that includes the interaction of people in the organization at a high level to analyze the organization potential for creating knowledge in the coalescent dimension.

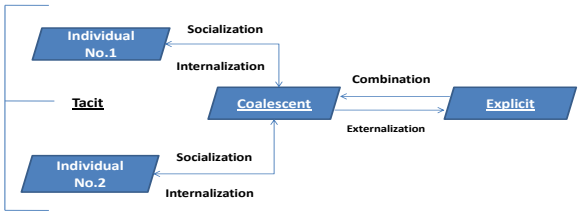


Fig.1. Updated Knowledge creation Process Flow – High Level

2.3 REFINED KNOWLEDGE CREATION PROCESS

Figure 2 shows the Refined knowledge creation process that includes the interaction of people or (experts) in the organization.

In the refined knowledge creation process[2], the creation of new tacit knowledge does not require the inclusion of explicit knowledge. As Coalescent knowledge matures it can be externalized via codification to become explicit knowledge which may be private or public. If there is only one Expert in the tacit dimension, then that expert would have both Tacit and Coalescent knowledge. If it requires to internalize some explicit knowledge, then the explicit knowledge would be converted to Coalescent knowledge. The Coalescent knowledge is shared between the expert and the creators of the explicit knowledge.

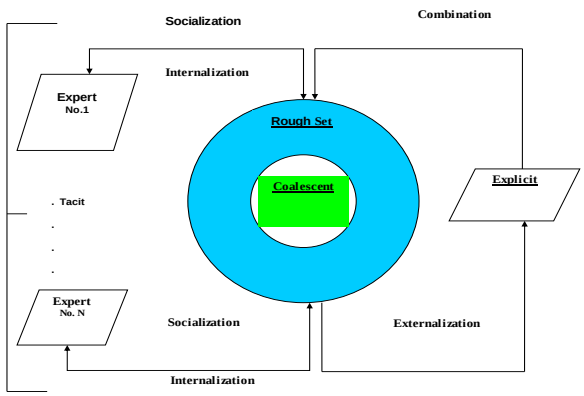


Fig.2. Refined Knowledge creation process Flow

Although the creators are not actively participating in the dialogue, the expert doing the internalization assigns them a virtual role. Knowledge that is shared by two or more expert's can be considered communal knowledge.

The formation of Coalescent knowledge from tacit dimension will be certain when the dimension includes minimum number of experts. Whereas the uncertainty arises in the knowledge creation process within the organization when the tacit dimension involves many number of experts.

Since the Rough set deals with the uncertainties, it can be effectively used to refine the Coalescent dimension and to make the actionable knowledge more certain.

The Rough set can make use of different experts tacit knowledge derived from similar organization in order to refine the uncertainty problems.

3. ACTIONABLE KNOWLEDGE BASED ON ROUGH SET

3.1 MODIFIED CLASSIC MANAGEMENT FRAMEWORK

The design of our knowledge management model is on the basis of classic management system [8]. The classic management process is comprised of four sub-processes: Planning, Organizing, Leading, and Controlling (PLOC)[8]. The controlling and planning sub-processes are connected through a feedback loop to ensure that the objectives of the plan are being met. The controlling function compares performance to the standards set in the planning process. If deviations are detected, the information is feed back to the planning process for changes in the plan that will cause the standards to be met. During the controlling and/or planning processes, an evaluation should be performed to determine why there was a deviation from standards.

There are two main modules in the proposed framework (as shown in figure 3), i.e. critical reflective practice, , and knowledge management modules. The framework is proposed to create actionable knowledge within the organization.

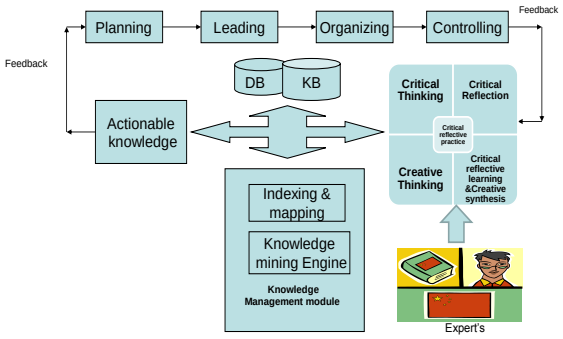


Fig. 3. A framework of modified classic management system

By adopting the critical reflective practice principals as defined by Van Aswegen [9] to an open group dialogue format, management consultant could make use of the Coalescent knowledge derived from the tacit dimension. Based on the formation of the uncertainty problems, the Coalescent knowledge can be refined by implementing the rough set concept in order to eliminate the uncertainty and to minimize the deviation from the standards. Critical reflective learning often results in new knowledge or a new perspective on existing knowledge, which is relevant to improving standards. Van Aswegen [9] further states "learning results in creative synthesis (consistency in thought and action). The individual decides the worth, accuracy, and validity of new ways of thinking and practices, then integrates these into their planning and operating practices."

Knowledge management module provides the following capabilities:

- Discover valuable knowledge assets from the data repository containing expert's personal data, tracked data of experts' performance and behavior, and data related to content sequences that were

presented in the past with the evaluation results according to that content sequence.
- Support the indexing and mapping of knowledge assets that are discovered by the knowledge mining engine.

3.2 PROPOSED METHOD

From the proposed framework, the use of critical reflective practice by management in operational group processes (how work gets done in the organization) will create new actionable knowledge in the coalescent knowledge dimension.

For the knowledge management module, knowledge mining engine is responsible for the synchronizing and knowledge mining processes. Indexing and mapping is a component for storing and searching knowledge assets to be used in the learning process. In this paper, it is concentrated on the knowledge mining engine that exploits rough set theory as a theoretical foundation to deal with precise and uncertain information systems.

The induced knowledge is represented as decision rules stored in the knowledge base. These rules are intended to be used as guidelines to achieve the objectives of the plan are being met.

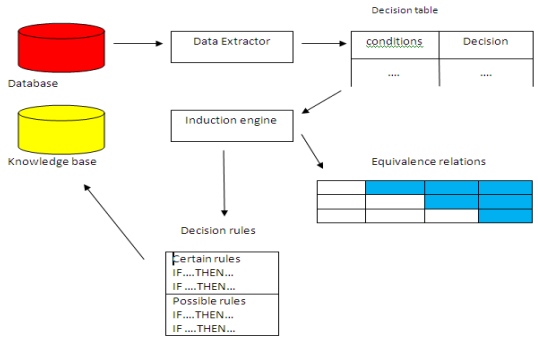


Fig. 4. An architecture of a knowledge induction module.

A database containing expert's profile and tracking records is a starting point of our knowledge induction method. A data extraction component (a data extractor module shown in figure 3) creates a decision table in a format appropriate for the knowledge induction engine. A set of equivalence relations is analyzed and two classes of rules, i.e. certain and possible rules, are derived and stored in the knowledge base. The proposed steps to induce decision-supported knowledge are demonstrated in the following section.

4. RUNNING EXAMPLE

The Expert data is as shown in Table 3(b) to explain the steps in inducing decision-supported knowledge. The hierarchical information on interval order that 81-100 > 61-80 > 41-60 > 21-40 > 0-20 is used as background knowledge for decision rule generalization. Suppose there is a request from the manager consulting the knowledge mining engine to create a set of decision rules to help deciding idea's level of the new expert based on the first pretest score. This expert got 52 points in the first pretest. The steps on inducing decision rules are as follows.

(I) The request asks about expert's level with score1 as a condition. Since score1 is not a core attribute, this attribute alone cannot be used to derive a set of equivalence relations. Hence, a reduct decision table containing score1 and score2 attributes as in figure 3(b) is constructed.

(II) Then, the following decision rules are generated.

Certain rules

Steps:

1. Extract the experts' information from the database
2. Create a decision table A = <U, A, d>, where d = decision attribute, A = a set of conditional

attributes, and U = a set of records, or universe, in a decision table

3. Pre-process A by removing attributes with very high number of distinct values, and discretizing (i.e., grouping values into intervals) attributes containing real values
4. Partition U into equivalence classes

5. Search for the first reduct *R*

6. Identify lower approximation (*bX*), upper approximation (*BX*), and boundary (*BN*) regions

7. From *R*, *bX*, *BX*, and *BN*, generate certain and possible rules

8. Generalize all decision rules using ontology or hierarchical information from the metadata

9. Insert rules into the knowledge base

IF (score1= 0-20 ^ score2= 81-100) THEN level = advanced

IF (score1= 21-40 ^ score2= 61-80) THEN level = advanced

IF (score1= 41-60 ^ score2= 41-60) THEN level = advanced

IF (score1= 0-20 ^ score2= 0-20) THEN level = basic

IF (score1= 0-20 ^ score2= 21-40) THEN level = basic

IF (score1= 0-20 ^ score2= 41-60) THEN level = basic

Possible rules

IF (score1=21-40 ^ score2=21-40) THEN level = advanced

(III) The induced decision rules are generalized according to the background knowledge. The final decision

rules are as follows.

R1: IF (score1 > 20 ^ score2 > 60) THEN level = advanced

R2: IF (score1 > 40 ^ score2 > 40) THEN level = advanced

R3: IF (score1 > 20 ^ score2 > 20) THEN level = possibly advanced

Advise from the knowledge induction engine:

The learning level depends on the score obtained from the second pretest.

IF score2 > 40 THEN level = advanced.

IF score2 > 20 THEN level = possibly advanced.

5. CONCLUSION

This paper describes the concept of tacit knowledge dimension and the formation of Coalescent knowledge from tacit dimension. As the tacit dimension increases, the uncertainty problem is eliminated through Rough set method. The concept of Classical Management Process is explained and is modified by the refined Coalescent knowledge through Rough set in order to minimize the deviation between the reference and the actual outcome. The proposed technique of decision rule induction to induce knowledge that can facilitate the development of actionable knowledge with in the classic management systems. The induction process is based on the rough set theory. It is assumed that the system with the availability of large data and knowledge repositories has high potential in producing valuable knowledge to support the organization. The framework of the system and the algorithm of decision rule induction has been proposed. The intuitive idea is illustrated trough running example. The proposed idea is general, hence it can be applied to any kind of domain. In future, it is planned to test the effectiveness of the framework with the real-world data.

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أسلوب المجموعات الصعبة لخلق معلومات ذات فاعلية داخل المؤسسة

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الملخص:

تقدم هذه الورقة البحثية بيئة مناسبة لتدعيم تطوير المعلومات ذات الفاعلية (المعلومات التي تستخدم لكي تخلق قيمة) في نظام الادارة التقليدي. لكي تساعد في نجاح المؤسسة في خلق معلومات ذات فاعلية يجب على مستشار الادارة ان يكون ملما بابعاد المعلومات. ان اجراءات خلق معلومات ذات فاعلية هي في الاساس اجراءات حوارية. فعلي سبيل المثال، تطوير اي منتج محكوم بعدة معلومات خبيرة متضمنة الانعكاس الحرج للتطبيق العملي وهي ديناميكية بطبيعتها وتم استنباطها من الخبرة وهي غير خطية ايضا.

في هذه الورقة البحثية تم اقتراح طريقة تعليم فنية ذكية جديدة يطلق عليها نظرية المجموعات الصعبة. ولقد عني بالتعليمات التأثيرية لكي توجه سريان مخطط المعلومات. ويمكن استخدام هذه التعليمات لدعم اتخاذ القرار لكي نحصل على المستهدف المخطط. في هذه الورقة البحثية تم مناقشة وتعديل اسليب ادارة المعلومات التقليدية باستخدام نظرية المجموعات الصعبة وتم شرح طريقة جديدة مقترحة باستخدام الطرق اللوغارتمية وتقديم امثلة محلولة.