Rough Set Based Decision Support System (RSBDSS) for e-Learning

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Abstract: E-learning is a planned form of teaching and learning experience that uses a wide spectrum of technologies including, Internet and WWW to deliver education at a distance. In this context, LMS is software for handling various management related activities in respect of learning and its delivery in online mode. To facilitate quality education, the identification & selection of various factors that may influence a students' academic performance is very important. The importance of personalization of learners' needs has now been realized and is agreed to by most of the e-Learners, authors and the managers of web-based education system. Working positively on these factors may improve the performance of the student. The proposed system may be seen as a helping hand to creators of contents, educators and teachers of the course. In today's scenario, Personalization is a topic of research and Rough set may contribute a lot. Rough sets may be seen as an emerging tool & technique in this respect. Rough set theory is particularly useful for discovering relationships and used to deal with imprecise or incomplete data. This process is commonly called knowledge discovery or data mining. E-learning systems like LMSs deal with a large number of students at a time, it is difficult to evaluate their level manually, in this context RSBDSS can act as an add-on with existing systems like LMS or LCMS to assist them as decision maker.

Key words: AI, DSS, e-learning, RSBDSS, rough set theory

1. Introduction

Nowadays Internet has become the most useful and powerful source of information. In order to effectively deal with the huge amount of information on the web, advanced web search engines have been developed for the task of retrieving useful and relevant information in multimedia form for its users [1]. A number of learners, educators and educational managers use web based learning systems. However, one of the major problems that are being faced by them is about lack of personalised education. Decision making & personalised form of information can help in improvement of e-learning.

Artificial Intelligence (AI) has evolved as one of the promising technology for achieving intelligence over web. To facilitate quality education, the identification & selection of various factors that may influence a students' academic performance is very important. Knowing these factors is important for parents & teachers working positively on these factors may improve the performance of the student [2]. Different characteristics & technologies of web 3.0 that may result in development of e-learning systems that may extensively benefit in providing facilities more personalised & better decision support system (DSS). By offering such approach, education system could play much better for student centric operation towards

positive improvement of his performance.

This paper is divided in 5 sections. In the first section, we briefly discuss the definitions of the discipline of e-learning and A.I. In the Second Section, we discuss preliminaries of Rough Set. In Section 4 and Section 5, we discussed about system overview of RBSDSS and Architecture and its design respectively. Components of RSBDSS architecture with internal process design of different stages are describe and explained. It also provides an Algorithm in support of working mechanism of the architecture.

2. Some Related Definitions

We briefly discuss the main aspects of the discipline of e-learning and A.I. in the next section.

E-learning: Rosenberg (2001) [3] Defines the term e-learning as, the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance". E-learning is based on three fundamental criteria suggested by Rosenberg [3]:

- Networked for instant updating, distribution, storage/retrieval and sharing of information.
- Content delivery via computer using WWW.
- It focuses on the broadest view of learning and learning solutions.

Thus, e-learning may be taken as the latest form of distance learning mediated by state-of-art technologies like Internet and World-Wide-Web [4]. We must remember that e-learning is much more than online training or Computer-Based Training (CBT), encompassing knowledge management and electronic performance support, Computer –conferencing enabling group communication, enabled by Internet and WWW is one the key characteristics of e-learning which makes it qualitatively much superior to the conventional distance learning paradigm [3], [5], [6].

Longmire (2001) states "e-learning covers a wide set of applications and processes such as computer-based learning systems, Web-based learning systems, virtual classrooms, and digital collaborative learning GroupWare packages. E-learning content is mainly delivered via Internet, intranet/extranet, audiotape and videotape; satellite broadcast, interactive TV, DVD and CD-ROM, and the still to emerge wireless application protocols (WAP) "[7].

Artificial Intelligence: A.I. plays a significant role in e-learning. Before discussing the role, we begin with explanation of some relevant concepts, tools and techniques of A.I. In this respect, first of all, we state three simple definitions of A.I. from completely non-specialists' point of view [8]:

1) A.I. is the study of making computers smart.
2) A.I. is the study of making computer models of human intelligence; and finally
3) A.I. is the study concerned with building machines that simulate human behavior [8].

Shalkoff [9] states, 'Perhaps broadest definition is that AI is a field of study that seeks to explain and emulate intelligent behavior in terms of computational processes'.

The definition, by Barr and Feigenbaum in The Handbook of Artificial Intelligence [10], "Artificial Intelligence is the part of computer science concerned with designing intelligent computer systems, i.e., systems that exhibit the characteristics we associate with intelligence in human behavior".

3. Preliminaries of Rough Set Theory

Rough set theory was introduced by Zdzislfaw Pawlak [11]-[13], Warsaw University of Technology, in the early 1980s. Rough set theory is particularly useful for discovering relationships in data. This process is commonly called knowledge discovery or data mining. It is also suited to reasoning about imprecise or incomplete data [11], [14]. Fuzzy set and rough set deals with the concept of vagueness in the information but unlike fuzzy set, rough set theory does not require degree of membership in dealing with vagueness. Rough set uses concepts of upper and lower approximation defined on the basis of set. We present our

framework of decision support system (DSS) on the basis of basic concepts of Rough sets.

3.1. Related Terms and Definitions

Rough set theory deals with data expressed in two-dimensional or matrix form of tables, called information tables or decision table. A Decision table is tabular representation of real world data. In the Figure 1, the shown table depicts a Decision table; each row of the table represents an individual object. The input of Decision table contains condition attributes and decision attributes. Table shown in the Figure 1, depicts the information of 9 students with conflicting inputs such as O:8 and O:9. Conditions attributes consists of scores of two test conducting on students such as sub1, sub2. The decision attributes of the table consisting result attributes.

Definition 1: A decision system is any system of the form A = <U, A, d>, where U is a non-empty finite set of objects called the universe, A is a non-empty set of objects and d ∉ A is the decision attribute[15], [16].

Table: student

9 / 3	Sub1	sub2	result
O:1	E	E	BASIC
O:2	E	D	BASIC
O:3	E	C	BASIC
O:4	E	C	BASIC
O:5	E	A	ADVANCED
O:6	C	C	ADVANCED
O:7	D	B	ADVANCED
O:8	D	D	ADVANCED
O:9	D	D	BASIC

Fig. 1. Information table or decision table.

Definition 2: Given a decision system A = <U, A, d>, then with any B ⊆ A there exists an equivalence or indiscernibility relation IA (B) such that

$$IA\ (B) = \{(x, x') \in UxU \mid \forall\ a \in B\ [a(x) = a(x')]\}.$$

Groups of similar objects are created based on the values of attributes [15].

Definition 3: Let A = <U, A, d> be a decision system, B ⊆ A, X ⊆ U and [x] B denote the equivalence class of IA(B). The B-lower approximation and B-upper approximation of X, denoted by bX and BX respectively, are defined by

$$bX = \{x \mid [x]B \subseteq X\} \text{ and } BX = \{x \mid [x]B \cap X \neq \emptyset\}[15], [16].$$

The definitions of approximations can be expressed in terms of granules of knowledge in the following Fig. 2.

The lower approximation of a set is union of all granules which are entirely included in the set; the upper approximation – is union of all granules which have non-empty intersection with the set; the boundary region of a set is the difference between the upper and the lower approximation of the set [17].

Definition 4: Let A = <U, A, d> be a decision system and P, Q ⊆A be sets of conditions, P ≠Q. The set P is the reduct of set Q if P is minimal (i.e. no redundant attributes in P) and the equivalence relations defined by P and Q are the same [15].

In order to reduce redundant and insignificant attributes, concept of reducts is emerged in Rough Set Theory, a Reduct is the minimal set of attributes preserving classification power on original data set A [17].

Intersection of all reducts is called core. Decision rules are generated from reducts and used for classification of objects.

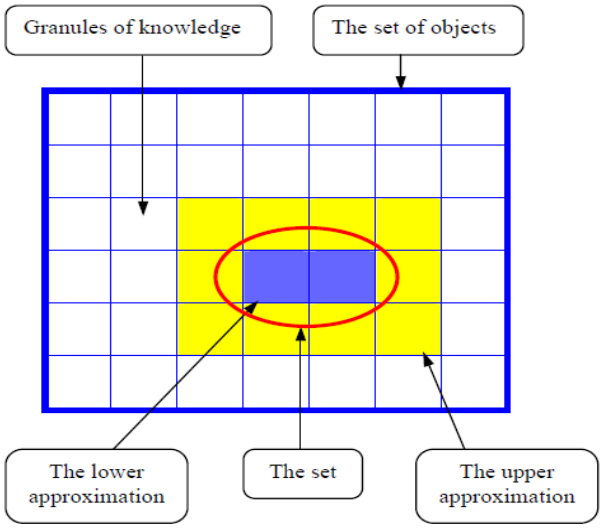

Fig. 2. Lower & upper approximations (Source: Zdzisław Pawlak).

4. RSBDSS System Overview

The importance of personalization of learners' needs has now been realised and is agreed to by most of the e-Learners, authors and the managers of web-based education system. We know the fact that the learners come from to different learning backgrounds, economic level, knowledge levels, learning styles, and even different abilities and hence; require different methodologies and styles to students of different backgrounds. Thus, the concept 'one size-fits-all' used in the conventional system, and even in some e-learning systems, is clearly a typical problem and solutions to the problem need to be considered. To overcome this limitation and enhance learning; RSBDSS is found to be helpful in the prediction of the personalized evaluation on the basis of different characteristics of learner.

We know the fact that learners have different characteristics, so, it is the very much required to have better prediction system to measure his/her characteristics. In today's scenario where e-learning systems deal with a large number of students at a time, it is difficult to evaluate their level manually, in this context RSBDSS can act as an add-on with existing systems like LMS or LCMS to assist them as Decision maker.

The RSBDSS system is designed to work along with LMSs. RSBDSS takes raw information as an input and then processes it, and finally, gives back required details to the LMS as an output. So, in this way it acts like a decision support system.

To facilitate quality education, identification & selection of various factors that may influence students and their academic performance are very important. Knowing these factors is important for parents as well as teachers. Working positively on these factors may improve the performance of the student. The proposed system may be seen as a helping hand to creators of contents, educators and teachers of the course. Using this approach, course content developers may create, customize & manage the content according to learner's level or expertise. Therefore, the process of development of course according to learners' requirements may be viewed as execution of portion or piece of learning content extracted from repository of content to match unique needs of different learners.

The core technology behind RSBDSS is Rough Sets Theory as an emerging technology in this respect. Rough set theory is particularly useful for discovering relationships in data. The process of discovering of

relationships is commonly called knowledge discovery or data mining. Rough set theory also is used to deal with imprecise or incomplete data. We have used Rough sets extensively in design of our decision support system (DSS). The DSS in education system could play much better role for student centric operation towards positive improvement of his performance.

5. RSBDSS Architecture

In this section, we discuss the proposed architecture RSBDSS that performs as a DSS in an e-learning environment.

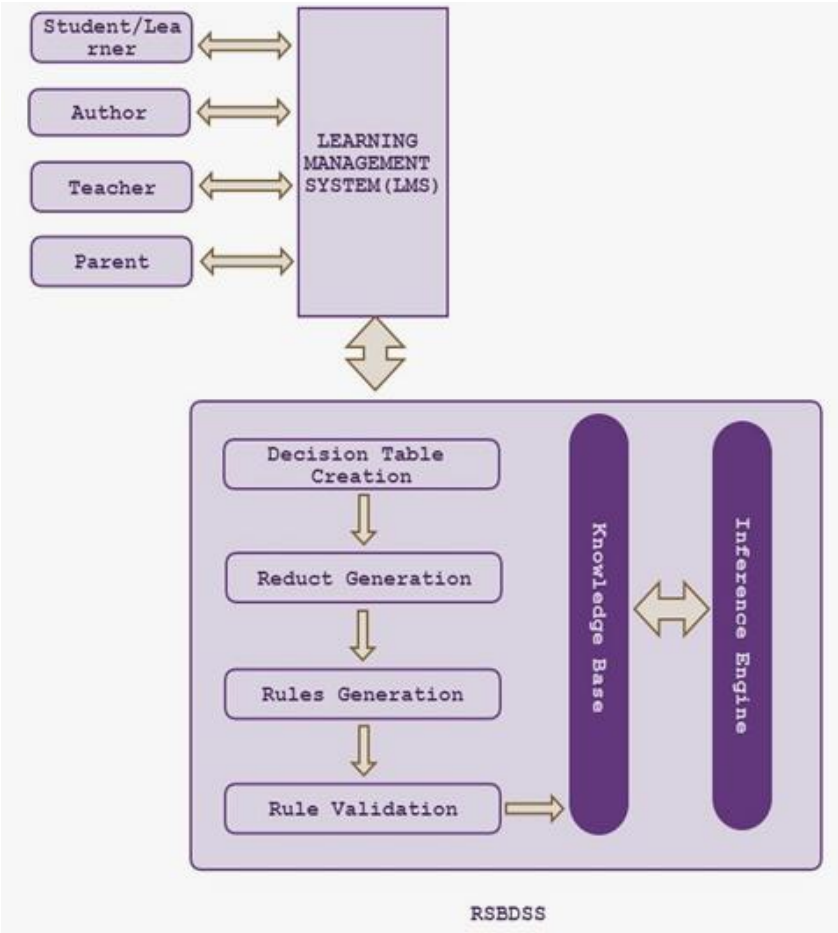

Fig. 3. RSBDSS architecture.

One of the objectives of the proposed system is to be generic and functional for different e-learning platforms. The design is based on a modular architecture that can be observed in the given Fig. 3. This system performs in the following manner:

First of all, The RSBDSS reads and gathers data from the e-learning platform and after having data in the system, it carries out some pre-processing tasks required to create raw data in desired form. Secondly, the next process of the RSBDSS is to process the data and induce rules. In the next phase, rules are stored in the knowledge base and then these rules are transferred to Inference Engine. Then, finally the results using the stored rules in some pre-defined manner, are made available to the e-learning platform which in turn, results made by RSBDSS are used for different users and purposes.

The whole system is composed of three basic components, namely, 1) Learning Management System as e-learning platform, 2) Users of the system, and 3) RSBDSS as decision support system. The role of each of these components is discussed below:

5.1. Learning Management System (LMS)

LMS is software for handling various management-related activities in respect of learning and its delivery in online mode. An LMS can help for planning, delivering, evaluation and management of learning contents. Also, it helps in managing thousands of students in accessing and their management in the process of online learning or e-learning. In the context of our framework, it's major role is in facilitating the following services to its users.

- GUI based rich User Interface for better user interaction and easy operations.
- User Registration module where users may include, student, learner, author, parent or even a teacher.
- Tools for creation and management of courses for both administrator and course creator.
- Tools for the administration of courses for assigning roles and users rights.
- Tools for testing and feedback.
- Tools for evaluation of course made for students.
- Tools for Student Registration process and Administration.
- Tools for Managing, scheduling, tracking, and content delivery in web based mode.
- Curriculum and Certification Management.
- Skills and Competencies Management.
- Individual Development Plan.
- Capability of reporting about various relevant issues.
- Training Record Management.
- Courseware authoring capabilities.
- Discussion board facility for establishing discussion on various issues.
- E-Commerce facility to facilitate purchasing of e-material.
- E-Portfolios facility to enable students and faculty members to assemble and share information online for documenting academic growth and career prospective.
- Online help 24×7.

We assume that the required LMS should atleast provide the basic facilities for User Registration, where users may include, student, learner, author, parent or even a teacher. LMS should also keep learner's details like student profile, background details, online activity details of student, and scores of students. These details are provided by LMS to the RSBDSS as an input to induce rules.

5.2. Users

Different types of users may avail the facilities mentioned above with technology. We have user as a student, user as a learner, user as an author or content developer, user as a Teacher and even user as a Parent of the learner/student.

User can benefit using RSBDSS in carrying out 'What-if" analysis of data for further decision making process. This information or analysis can help Authors/contents developers to choose which subject or content would be beneficial for a learner or even teachers and parents, so that they may know better about the level of a learner not only from the academic performance, but also from various other characteristics that also affects a learner performance.

5.3. RSBDSS

This is the main module where rules are induced according to the data gathered from LMS. Input details are Learner Profile, Learner Background, and learning style s in online mode and Learner Evaluations. This main module includes the following sub-processes and sub-modules.

Decision Table creation: Rough set theory deals with data expressed in two-dimensional or matrix form of tables, called information tables or decision table. A Decision table is tabular representation of real world data. Each row of the table represents an individual object. The input of Decision table contains condition attributes and decision attributes. The information gathered from LMS is in the form of a table or in XML, text, excel file or in any other format that can easily be transported in online mode. The mathematical and practical foundations of Rough Set Technology are explained in next sections.

Reduct Generation and Rules Generation: In order to reduce redundant and insignificant attributes, concept of reduct is emerged in Rough Set Theory; a Reduct is the minimal set of attributes preserving classification power on original data set [14]. Decision rules are generated from reducts and used for classification of objects. Rules are calculated on the basis of algorithms which are discussed in detail in next sections. Decision rules generated with the help of input data are comprised of certain rules generated from the positive region, negative region, and from the boundary region.

Some examples of Rules, which are formed after this process, are shown below:

If subject1 has E grade and subject2 has E grade, then result will be Basic level

If subject1 has E grade and subject2 has D grade, then result will be Basic level

If subject1 has E grade and subject2 has C grade, then result will be Basic level

If subject1 has E grade and subject2 has A grade, then result will be Advanced level

If subject1 has C grade and subject2 has C grade, then result will be Advanced level

If subject1 has D grade and subject2 has B grade, then result will be Advanced level

Knowledge base and Inference Engine: All the rules are sent to the knowledge base which basically store rules in some logical order. These rules are generated using three different regions as discussed above. Inference Engine provides interface to an LMS. Interface engine converts all rules induced, into the technical format that is understood by the LMS. All the requests are handled by the system finally result into a response which is the responsibility of Inference engine. The Inference Engine also provides clean and efficient web interface to LMSs in delivering meaningful data from rules that further helps in achieving better decision support.

LMS gathers results generated by inference engine as an input and for further processing of personalized decision making according to learners' behavior.

Algorithm:

Input: User Query generated using LMS as an interface.

Output: Decision Rules.

Step 1: Extract Learner's details as Input from LMS.

Step 2: Create Decision Table in terms of *Condition Attributes* and *Decision Attributes*.

Step 3: Partition all the records/rows into *equivalence classes* and calculate *Reduct*.

Step 4: Generate Rules from *Positive Region, Negative Region and Boundary Region*, and validate rules.

Step 5: Insert Rules into the *knowledge base*.

Step 6: Produce required results from the *knowledge base* using *inference engine* and finally, send to the LMS.

Characteristics and Advantages of RSBDSS:

- Course selection advising on the basis of learner level of expertise and understanding.
- Help in better prediction and selection of course material/contents to the learner/student by the selectors.
- Better evaluation of learner's level of understanding using RSBDSS.
- Teachers and Parents may know about the student performance, not only on the basis of marks, but other factors that influence performance of a student.

6. Conclusion

In order to effectively deal with the huge amount of information on the web, advanced web search engines have been developed for the task of retrieving useful and relevant information in multimedia form for its users. A number of learners, educators and educational managers use web based learning systems. However, one of the major problems that are being faced by them is about lack of personalised education. Decision making & personalised form of information can help in improvement of e-learning.

The primary hypotheses have directed the research work presented in this paper that, it is possible to implement as effective support tool for learners, managers and other stake holders like parents, in their respective fields of concern, so that the learners are helped in their learning efforts that may not only help them in learning efficiently, but also may facilitate in their creativity. LMS is software for handling various management-related activities in respect of learning and its delivery in online mode. An LMS can help for planning, delivering, evaluation and management of learning contents.

AI can be perceived as a tool that can be incorporated in not just academic programmes of a university and in learning materials, but also in how the University ensures more personalised evaluation, personalised course & personalised content creation and more importantly, to adapt to the varied needs and characteristics of its learners. Therefore, this paper aims to provide a snapshot of how AI can complement, enhance and benefit the teaching and learning experience at an ODL institution like IGNOU. Implementing AI based personalised decision support system in an institution like IGNOU, may be considered as a step towards quality education as well as to learners. This paper proposes framework of Rough set theory(RST) based decision support system (DSS) that may work in conjunction to current LMSs. By offering such approach, education system could play much better for student centric operation towards positive improvement of his performance.

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