


evaluation of Concepts Understanding

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Abstract: The aim of this paper is to present an approach for following students’ progress in obtaining new knowledge based on rough sets approximations. Consecutive responses of each individual learner to automated tests are placed in appropriate rough sets approximations. The resulting path provides strong indication about the current level of learning outcomes.

Key–Words: Rough sets approximations, knowledge, intelligent systems, visualization

1 Introduction

Students’ knowledge evaluation has been a subject of special interest to various research communities. Automated tests appear to be among the most popular ways of providing immediate feedback to both students and test designers. Every test designer has to give serious considerations to logical reasonings involved in the process decision making. Using Boolean logic limits system’s responses to true or false and cannot therefore recognize other occurrences like f. ex partially correct or incomplete answers. Boolean logic appears to be quite sufficient for most everyday reasonings, but it is certainly unable to provide meaningful conclusions in presence of inconsistent and/or incomplete input, [12] and [16]. This problem can be resolved by applying methods from the theory of rough sets approximations.

The aim of this paper is to present an approach for following students’ progress in obtaining new knowledge based on rough sets approximations. Consecutive responses to automated tests of each individual learner are placed in appropriate rough sets approximations. The resulting path provides strong indication about the current level of learning outcomes and points possible inconsistencies related to tests’ contents.

The rest of the paper is organized as follows. Section 2 contains definitions of terms used later on. Section 3 explains how to combine personal responses. Section 4 contains the conclusion of this work.

2 Background

Let $P$ be a non-empty ordered set. If $\sup\{x, y\}$ and $\inf\{x, y\}$ exist for all $x, y \in P$, then $P$ is called a lattice [9]. In a lattice illustrating partial ordering of knowledge values, the logical conjunction is identified with the meet operation and the logical disjunction with the join operation.

Five-valued logic presented in [10] is based on the following truth values: uu - unknown or undefined, kk - possibly known but consistent, ff - false, tt - true, and ii - inconsistent. Intermediate truth values are used to facilitate the process of comparing degrees of certainty among contexts.

2.1 Rough Sets

From classical stand point of view a concept is well defined by a pair of intention and extension. Existence of well defined boundaries is assumed and an extension is uniquely identified by a crisp set of objects. In real life situations one has to operate with concepts having grey/gradual boundaries, like f. ex. partially known concepts, [30], undefinable concepts, and approximate concepts, [18].

Rough Sets were originally introduced in [23]. The presented approach provides exact mathematical formulation of the concept of approximative (rough) equality of sets in a given approximation space. An approximation space is a pair $A = (U, R)$, where $U$ is a set called universe, and $R \subseteq U \times U$ is an indiscernibility relation.

Equivalence classes of $R$ are called elementary sets (atoms) in $A$. The equivalence class of $R$ de-
terned by an element \( x \in U \) is denoted by \( R(x) \). Equivalence classes of \( R \) are called granules generated by \( R \).

The following definitions are often used while describing a rough set \( X, X \subseteq U \):
- the \( R \)-upper approximation of \( X \)
  \[
  R^*(x) := \bigcup_{x \in U} \{ R(x) : R(x) \cap X \neq \emptyset \}
  \]
- the \( R \)-lower approximation of \( X \)
  \[
  R_*(x) := \bigcup_{x \in U} \{ R(x) : R(x) \subseteq X \}
  \]
- the \( R \)-boundary region of \( X \)
  \[
  RN_R(X) := R^*(X) - R_*(X)
  \]

2.2 Assessment
Research-based good practice addressing the pedagogical, operational, technological, and strategic issues faced by those adopting computer assisted assessment is described in [4], [5], and [6]. Expert and theoretical knowledge about the use of technology for assessment is offered in [7], [8], and [20]. A method enabling the instructor to do a post-test correction to neutralize the impact of guessing is developed in [14]. The theory and experience discussed in the above listed literature was used while developing our assessment tools.

A personalized intelligent computer assisted training system is presented in [22]. An intelligent tutoring system that uses decision theory to select the next tutorial action is described in [19]. A model for detecting student misuse of help in intelligent tutoring systems is presented in [2]. An investigation of whether a cognitive tutor can be made more effective by extending it to help students acquire help-seeking skills can be found in [17].

A proliferation of hint abuse (e.g., using hints to find answers rather than trying to understand) was found in [1] and [17]. However, evidence that when used appropriately, on-demand help can have a positive impact on learning was found in [25], [27], and [29].

A level-based instruction model is proposed in [21]. A model for student knowledge diagnosis through adaptive testing is presented in [13]. An approach for integrating intelligent agents, user models, and automatic content categorization in a virtual environment is presented in [26].

The Questionmark system [33] applies multiple response questions where a set of options is presented following a question stem. The final outcome is in a binary form, i.e. correct or incorrect because the system is based on Boolean logic [11], [28].

3 Understanding of a Concept
The main focus in this section is on the idea of connecting correct, incorrect and partially correct responses, and rough sets approximations. The five truth values placed in a lattice can be seen in Fig. 1.

Assessment of students’ understanding of a concept is proposed employing multiple choice tests. The system is designed in a way that a new trial brings different questions and/or answer combinations but related to the same concept. A test related to a particular concept can be taken several times. In order to obtain a higher degree of certainty in the decision process on whether a concept is sufficiently understood we involve three different questions related to that concept. This gives an opportunity to the student apply his/her understanding in different situations and decreases the chances of "just a lucky guess".

A test consists of three questions. Each question is followed by three alternative answers and a student can choose exactly one of them or skip that question. An alternative answer can be correct \( c \), incorrect \( i \) or partially correct \( p \) and lack of a response is denoted by \( n \). Thus an outcome of a test will be one of the twenty triplets: \( ccc \) - three correct answers, \( ccp \) - two correct answers and one partially correct answer, \( ccn \) - two correct answers and one unanswered question, \( cci \) - two correct answers and one incorrect answer, \( cpp \) - one correct answer and two partially correct answers, \( cmm \) - one correct answer and two unanswered questions, \( cii \) - one correct answer and two incorrect answers, \( cpn \) - one correct answer, one partially correct answer, one unanswered question, \( cpi \) - one correct answer, one partially correct answer, one incorrect answer, \( cni \) - one correct answer, one unanswered question, and one incorrect answer, \( ppp \) - three partially answers, \( ppi \) - two partially answers and one unanswered question, \( ppi \) - two partially answers and
one incorrect answer, $pnn$ - one partially answer and two unanswered questions, $pni$ - one partially answer and two incorrect answers, $pni$ - one unanswer question and one incorrect answer, $nnn$ - three unanswered questions, $nni$ - two unanswer question and one incorrect answers, $nni$ - one unanswer question and two incorrect answers, $nni$ - three incorrect answers.

In an attempt to obtain a clear presentation we first group all answer triples in four rough set approximations as in Fig. 2, Fig. 3, Fig. 4, and Fig. 5 with respect to the number of correct answers and the level of consistency of each answer combination. The four granules in lower approximations are 'homogeneous' (three answers of the same type, f. ex. $ccc$) and have no common elements. The rest of the granules in lower approximations have similar structure, i.e. two answers of the same type. Any two connected by a line inhomogeneous granules have one common element.

Test results of a student can take place in the same rough set approximation or in different rough set approximations.

Moving from one 'homogeneous' granule to another 'homogeneous' granule in the lower approximation set indicates a serious change. A student who has such test results is strongly recommended to repeat the test in order to conform the tendency.

Appearance of a single student consecutive test results the lower approximation set is of a particular importance to the test designer. It might indicate serious inconsistencies with respect to level of difficulties, formulation and even contents of the pool of questions. Another place to look at is answer alternatives attached to each question. Some of them could be either too obvious, or too vague or simply misleading.

Moving from one 'inhomogeneous' granule to another granule indicates a moderate change. Appropriate reading material is suggested before taking another trial.

4 Conclusion

Information extracted from imprecise and incomplete data is often difficult to classify. Therefore, precise reasoning rules are difficult and some times impossible to use. Applying rough sets approximations facilitates a balance between between accuracy and precision.

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