Web-Based Assessment System Applying Many-Valued Logic

Sylvia Encheva
Haugesund University College, Norway

Sharil Tumin
University of Bergen, Norway

INTRODUCTION

The issue of rewarding partially correct answers has been addressed by many authors (Guzman, E. & Conejo, R., 2004, Gardner-Medwin, A.R. 1995, Huffman, D, Goldberg, F., & Michlin, M. 2003). Intelligent systems have been designed to assign scores related to the importance of missing or incorrect part of an answer. Such systems are meant to facilitate the process of knowledge assessment. While trying to be efficient in evaluating students' responses these systems operate with the answers to a single question addressing learning a new term, understanding a new concept or mastering a new skill. However, experimental practice shows that asking several questions about the same item results in inconsistent and/or incomplete feedback, i.e. some of the answers are correct while others are partially correct or even incorrect.

A large number of computer based systems and thus automated assessment systems lack the ability to reason with inconsistent information. Such a situation occurs when, f. ex. a student answers to two questions about one item and one of the answers is correct and the other one is incorrect or missing. Reasoning by applying classical logic cannot solve the problem because the presence of contradiction leads to trivialization, i. e. anything follows from 'correct and incorrect' and thus all inconsistencies are treated as equally bad (Priest, 2001).

In this paper we discuss how to assess students' understanding of new terms and concepts, shortly after they have been introduced in a subject. Application of **many-valued logic** allows the system to give meaningful responses in the presence of inconsistencies. Decision making rules, an intelligent agent is applying for assessing students' understanding of new terms and concepts are presented. Such rules distinguish between students' hesitation in the process of giving an answer and lack of knowledge. We propose use of the generalized **Lukasiewicz**'s logic in a Web-based assessment system as a way of resolving problems with inconsistent and/or incomplete input.

BACKGROUND

A brief overview of a six-valued logic, which is a generalized **Kleene**'s logic (Kleene, S., 1952), has been first presented by Moussavi, M. & Garcia, N., 1989. Fitting, 1991 developed further this logic by assigning probability estimates to formulas instead of non-classical truth values.

The six-valued logic distinguishes two types of unknown knowledge values - permanently or eternally unknown value and a value representing current lack of knowledge about a state (Garcia, O.N. & Moussavi, M., 1990).

Two kinds of negation, weak and strong negation are discussed in Wagner, G., 1994. Weak negation or negation-as-failure refers to cases when it cannot be proved that a sentence is true. Strong negation or constructable falsity is used when the falsity of a sentence is directly established.

The semantic characterization of a four-valued logic for expressing practical deductive processes is presented by Belnap N.J., 1977. In Gurfinkel, A. & Chechik, M. 2005, it is shown that additional reasoning power can be obtained without sacrificing performance, by building a prototype software model-checker using **Belnap**'s logic.

Bi-dimensional systems representing and reasoning with temporal and uncertainty information have appeared also in Felix, P., Fraga, S., Marin, R., & Barro, S., 1999, and Mulsliner, D.J., Durfee, E.H., Shin, K.G., 1993.

A level-based instruction model is proposed by Park, C., & Kim, M., 2003. A model for student knowledge diagnosis through adaptive testing was developed by Guzman, E. & Conejo, R., 2004. An approach for integrating intelligent agents, user models, and automatic content categorization in a virtual environment is presented by Santos, C.T., & Osorio, F.S., 2004.

The Questionmark system at the University of Leeds applies multiple response questions where a set of options are presented following a question stem and the student can select any number and combination of those options. They are significantly more complex than multiple choice questions where the student can select only one among the suggested options. If a student marks some of the correct options (but not all) and or some of incorrect options his/her response can be correct, incorrect, partly correct or partly incorrect. The final outcome is correct or incorrect because the system is based on Boolean logic (Goodstein, R. L., 2007).

MAIN FOCUS OF THE CHAPTER

The test consists of two questions. According to the result of a test, understanding of a term or concept is achieved if a student gives a correct answer to questions about that term or concept. Such tests are placed after a new term or concept has been introduced in the theoretical part of a tutoring system. Questions in such tests should provide information about

- the student's knowledge,
- the subtler qualities of discrimination, judgement, and reasoning necessary in scientific reasoning,
- evaluate the student's judgement as to whether cause and effect relationships exist, and student's comprehension of a described situation.

Understanding of a Term

For evaluating understanding of a single term we propose a test where the choices can result in a correct answer, incorrect answer or unanswered question.

- Two correct answers imply understanding of that particular term. The process of questioning is terminated.
- One correct answer and one unanswered question imply some doubt about the student's understanding of that particular term. The system first provides additional explanations and then suggests to the student to answer one new question taken from the database.
- One correct answer and one incorrect answer imply doubt about the student's understanding of that particular term. The system first provides additional explanations and then suggests to the student to answer two questions where one new question is taken from the database and the other question is taken from the first trial and has received an incorrect answer.
- Two unanswered questions imply uncertainty about the student's understanding of that particular term. The system first provides additional explanations and then suggests two new questions taken from the database.
- One incorrect answer and one unanswered question imply doubt about the student's understanding of that particular term. The system first provides additional explanations and then suggests to the student to answer the same questions.
- Two incorrect answers imply lack of understanding of that particular term. The system first provides additional explanations and then suggests to the student to answer the same questions plus one new question taken from the database.

If the second set of responses contains an incorrect answer and/or unanswered questions the system advises the student to work more with the originally provided learning materials and terminates the automated questioning process. We believe that several rounds of questioning would make the learning process time consuming for the student and thus disturb the learning flow.

However, the student can start a new assessment of his/her understanding of that particular term at any time he/she wants.

Understanding of a Concept

For evaluating understanding of a concept we propose a test with two questions where the choices can result in correct answer, partially correct answer, wrong answer or unanswered question.