APPLICATION OF FUZZY LOGIC TO DIAGNOSTIC TESTING IN AN E-LEARNING ENVIRONMENT

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ABSTRACT

In an e-Learning environment, before a student moves on to the next module a diagnostic test is given from which a grade is provided. However, it is far more useful to the student if he is given some indication as to his actual capability in relation to the instructor's expectations. A letter grade or a numerical score (except at the extreme ends of the range) while desirable, does not provide sufficient insight into how the student fairs. What is needed is feedback to the student that helps him in his continual improvement in the subject matter. It is the myriad of variables such as, the student's speed in working out the problems, guessing, and the fraction of correctly answered problems. A careful consideration of these new variables gives this investigation a fresh outlook to the problem of diagnosis that has not been previously addressed. This article presents an application of Fuzzy Logic to diagnose a student's mastery of a narrow sliver of subject matter that he has studied. Recommendations are then given as to how he should proceed with his studies. The power of this approach lies in the ability of the computer administrating the diagnostic test to track a student's problem-solving speed for each and every problem that is attempted. Interestingly it is also possible to determine if the student made guesses instead of actually working out the correct answers to the problems. For diagnostic purposes, a correct answer from exercising a guess should not count towards the number of correct answers but as an unanswered question. Such a capability is not available for in-class tests because the actual answering speed for each question is not tracked, nor is it possible to determine if a correctly answered problem comes from guessing at the answer. This article describes the workings of a Fuzzy Logic diagnostic program and how it addresses all these interesting variables and incorporates them into a useful tool for assisting e-learning students in determining their mastery of the subject matter.

KEYWORDS

Fuzzy logic, e-Learning, Diagnostic testing

INTRODUCTION

In the past decade there has been a rapid increase in the use of information and communication technologies for instruction at many educational institutions. Recent years have also seen an exponential rise in the educational cost structure of many such institutions. It is generally perceived that such costs can be contained with the application of the aforementioned technologies to teaching and learning. In actual fact, application of these technologies has resulted in more than just increases in efficiencies (and therefore containment in costs). There have been improvements in quality, teaching and learning effectiveness, knowledge assessments, as well as in the breadth and speed of educational dissemination.

One of the areas of interest to the current investigators is in the area of diagnostic testing. In an introductory quantitative course such as Statistics, Calculus, Linear Algebra, or even Differential Equations, the size of such classes are generally large. Much time and energy have to be expended on the part of the instructor to generate and give in-class assessments, as well as valuable class time used up in determining student mastery of the subject matter. In an e-learning environment, however, tests can be given very soon after students have been presented the material to ensure that they have acquired the mechanics of solving a particular type of problem just introduced. The purpose of the diagnostic test, therefore, is not to assign grades to students, but to provide them with quick and timely feedback on their level of understanding and their ability to solve related problems. Clearly, such tests delivered on-line and graded automatically, can be repeatedly given to students at their convenience. They do not have to wait until a given date and time to take the test in a particular setting as in-class students do, nor are grades or points given that stays on record. The existence of extensive repositories of problems facilitate the process of problem generating each time the testing procedure is invoked so that a student can be tested again almost right away if he had not done well in prior tests on the same material. This approach works well so long as no long-winded derivations are required as part of the test. Writing out equations in a virtual environment is still a challenge. (Caprotti, 2007, Maplesoft). At this point, it may still be more convenient and efficient for e-learning students in quantitative courses to work out the problems on paper and find from a set of choices, the correct answer (Nascy, 2004).

FUZZY LOGIC

Lofti Zadeh, the founder of fuzzy logic, contends that a computer cannot solve problems as well as humans unless it is able to duplicate the imprecision in the thinking characteristics of a human being. Very often, we rely on fuzzy expressions such as "often," "very good," or "tall" while a computer current is limited to true-or-false, everything-or-nothing, which are crisp modes of logic. Interestingly, this idea of fuzziness has actually taken root. Over the past four decades, fuzzy logic has actually blossomed in the quantitative fields of engineering (Ross, 2010) as well as in business and finance (Von Altrock, 1997), fields that one would think need precision. So would it be when one thinks of assessments. The idea of pairing fuzziness with testing, as the investigators are trying to present in this article will, prima facie, also appear to be ridiculous.

There is nothing fuzzy about fuzzy logic. It is actually a quantitative science, and is fuzzy in name only. What fuzzy logic is able to handle is the imprecision that we humans use on a daily basis and yet, not only are we able to function with such imprecision, we thrive on it. Take for as example of a student being given a grade of 75%. To an elementary school student in arithmetic that would have been a failure in the test, but to a postgraduate student in Advanced Dynamics, that might have been an excellent grade! So, a crisp numerical number does not necessarily mean the same thing to everyone, nor would it even mean the same thing for different postgraduate courses given by different instructors. In a similar way, fuzziness would also be imprecise, just as how one would consider another as "rich," vary widely among different peoples in different parts of the world.

The primary objective of this article is not fuzzy logic, but is in the use of fuzzy logic for diagnostic assessment. For a more in-depth understanding of fuzzy logic, the reader is encouraged to look into introductory texts such as (Chen, 2001). This article will refrain from getting engrossed in the mechanics of mathematical manipulations in fuzzy logic, but instead will concentrate on using the Fuzzy Logic Toolbox, a set of routines (Mathworks, 2010), written in Matlab. This toolbox enables the user to go through the process of defining membership functions for the various crisp inputs (a process called fuzzification), the rule-base for processing the resulting fuzzy inputs,