Hints, Learning Styles, and Learning Orientations

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Abstract: Evaluation of hints related learning styles and learning orientations is in the main focus of this work. A hint is regarded as useful to a student if the student has succeeded to solve a problem after using it. The decision making process is based on the common assumption that if given a choice between two alternatives, a person will choose one.

Key–Words: Ordered sets, help functions, intelligent systems

1 Introduction

Developing a cognitive tutor involves creating a cognitive model of student problem solving by writing production rules that characterize the variety of strategies and misconceptions students may acquire. Cognitive Tutors have been successful in raising students’ math test scores in high school and middle-school classrooms, but their development has traditionally required considerable time and expertise, [8].

The Cognitive Tutor, [7] is able to understand student knowledge and problem-solving strategies through the use of a cognitive model. A cognitive model represents the knowledge that an ideal student would possess about a particular subject. 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 [14].

The process of delivering hints in an intelligent tutoring system has been discussed in [20]. A taxonomy for automated hinting is developed in [19]. The role of hints in a Web based learning systems is considered in [6].

This work is intended to facilitate automated provision of hints via an intelligent tutoring system, applying mathematical methods from partially ordered sets. Our approach to evaluate help functions will avoid the influence of the above mentioned subjective factors since a help function in this work is regarded as useful to a student if the student has succeeded to solve a problem after using it.

The rest of the paper is organized as follows. Section 2 contains definitions of terms used later on. Section 3 is devoted to ordered sets. Section 4 explains how to rank hints according to learning styles and orientations and Section 5 is devoted to a system description. Section 6 contains the conclusion of this work.

2 Background

A method enabling the instructor to do a post-test correction to neutralize the impact of guessing is developed in [12]. The theory and experience discussed in the above listed literature was used while developing assessment tools.

A personalized intelligent computer assisted training system is presented in [16]. Applying many-valued logic in practical deductive processes related to knowledge assessment, evaluating propositions being neither true nor false when they are uttered, [11].

2.1 Learning Styles and Orientations

Learning styles describe the influence of cognitive factors where learning orientations describe the influence of emotions and intentions.

In [13] learning styles are defined as the “composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment,” while in [18] they are considered to be the “educational conditions under which a student is most likely to learn.”

Learning styles group common ways that people learn, [9]. The following seven learning styles are presented there: visual, aural, verbal, physical, logical, social and solitary.

The learning orientations model in [15] refers to four categories of learning orientations: transforming,
performing, conforming, and resistant learners.

Learning orientations describe an individual’s disposition to approach, manage, and achieve learning intentionally and differently from others, [24]. The following factors having impact on intentional learning success and influence individual learning differences are listed: affective learning focus, learning independence, and committed strategic planning and learning effort.

2.2 Hints in Intelligent Tutoring Systems

Student navigation in an automated tutoring system should prevent students from becoming overwhelmed with information and losing track of where they are going, while permitting them to make the most of the facilities the system offers, [10].

A proliferation of hint abuse (e.g., using hints to find answers rather than trying to understand) was found in [14]. However, evidence that when used appropriately, on-demand help can have a positive impact on learning was found in [17].

The process of delivering hints in an intelligent tutoring system has been discussed in [20]. A taxonomy for automated hinting is developed in [19]. The role of hints in a Web based learning systems is considered in [6].

3 Ordered Sets

Two very interesting problems are considered in [4], namely the problem of determining a consensus from a group of orderings and the problem of making statistically significant statements about ordering.

Definition 1 An ordered set (or partially ordered set or poset) is an ordered pair \((P, \leq)\) of a set \(P\) and a binary relation \(\leq\) contained in \(P \times P\) called the order (or the partial order) on \(P\) such that

1. The relation is \(\leq\) reflexive. That is, each element is related to itself: \(\forall p \in P : p \leq p\)

2. The relation \(\leq\) is antisymmetric. That is, if \(p\) is related to \(q\) and \(q\) is related to \(p\), then \(p\) must equal \(q\): \(\forall p, q \in P : [(p \leq q) \land (q \leq p)] \Rightarrow (p = q)\)

3. The relation \(\leq\) is transitive. That is, if \(p\) is related to \(q\) and \(q\) is related to \(r\), then \(p\) must equal \(r\): \(\forall p, q, r \in P : [(p \leq q) \land (q \leq r)] \Rightarrow (p \leq r)\).

A relation \(I\) is an indifference relation when given \(AIB\) neither \(A > B\) nor \(A < B\) has place in the componentwise ordering. A partial ordering whose indifference relation is transitive is called a weak ordering.

If given two alternatives, a person is finally choosing only one. The natural extension to more than two elements is known as the 'majority rule' or the 'Condorcet Principle'. A relation \(R(L_1, L_2, ..., L_k)\) is constructed by saying that the pair \((a, b) \in R\) if \((a, b)\) belong to the majority of relations \(L_i\).

The linear orderings \(a\ b\ c\ a\ c\ a\ b\) leading to \(R = \{(a, b), (b, c), (c, a)\}\) (three-way tie), illustrate the 'paradox of voting'.

3.1 Social Welfare Function

If given a choice between two alternatives, a person will choose one. Thus obtained partial orderings appeared to be all linear orders since each pair of alternatives is compared. A social welfare function acts on \(k\)-tuples representing either weak or linear orderings of \(k\) individuals for \(m\) alternatives. The representation of an individual’s ordering can be thought of as a column vector in which an integer in position \(i\) represents the preference level the individual assigns to alternative \(i\). Thus \(k\) individuals presented with \(m\) alternatives can illustrated by \(k\)-tuples of orderings in a \(m \times k\) matrix \(A\) of integers of preference levels.

Theorem 2, [4] provides an existing social welfare function.

Theorem 2 There is a unique social welfare function satisfying Axioms 0-4. It is given by: \(i\) is preferred to \(j\) if and only if the sum of the row of \(A\) corresponding to \(i\) is larger than the sum of the row of \(A\) corresponding to \(j\), and otherwise the social ordering is indifferent between \(i\) and \(j\).

Two elements \(a\) and \(b\) where \(a \neq b\) and \(a, b \in P\) are comparable if \(a \leq b\) or \(b \leq a\), and incomparable otherwise. If \(\forall a, b\) where \(a, b \in P\) are comparable, then \(P\) is chain. If \(\forall a, b\) where \(a, b \in P\) are incomparable, then \(P\) is antichain.

4 Ordering of Help Functions

In this scenario students are suggested to solve problems via an intelligent tutoring system. The system provides assistance in a form of help functions on a user request. Three types of help functions called \(a, b, c\) respectively are available. They can contain f. ex. theoretical rules, hints and solutions of similar problems. The students’ responses are saved in a database. The goal is to find out in which order help functions related to a particular problem should be presented to a new student and in which order help functions should be presented to a student who has been using the system when the student is requesting
help with respect to a new problem. The system recognizes a help function as a useful one if a student provides a correct answer after that function has been presented to her/him.

Using nested parentheses one can represent the partial ordering structure in an application internally. Let the alphabets in this definition be ’( ), a, b, c’. The use of parentheses is to signify the position of ordering of a particular element ’a’, ’b’, or ’c’, where ’( )’ signifies level 1 - the top most level, ’(( ))’ signifies level 2, and ’((( )))’ signifies level 3.

Since the distance between partial orderings is unique than the distance between ’adjacent orderings’ is 1, [4]. Based on students’ responses a content provider can follow the process of responses clustering and make appropriate adjustments in contents of a problem or the related help functions or both. The It can also be used to track down the effect of help functions to each student and thus provide better individualized assistance.

When a pattern of clustering does not show any significant value but is evenly distributed amongst the twelve ordering pattern then one can conclude that none of the help functions were helpful for the students study progress. The help functions need to be redesigned.

4.1 Distances Between Orderings Where Two of the Functions are Considered to be Equally Helpful

The observed distances between two orderings in a case two of the functions are considered to be equally helpful are either 2 or 4. Illustration details:

Orderings (a(bc)) and ((ac)b)
In the first ordering we observe one function on level 1 and two functions on level 2, Fig. 1. In the second ordering we observe two functions on level 1 and one function on level 2, Fig. 2.

Note that the function on level 1 in the first ordering is still on level 1 in the second ordering while one of the functions on level 2 in the first ordering is on level 1 in the second ordering, Fig. 3. The distance is 2.

From ordering (ab(c)) to ordering (c(ab))

All functions change their levels of belonging, Fig. 4. The distance is 4.

From ordering (a(bc)) to ordering (b(ac))
Both orderings have the same structure, Fig. 5.

Two of the functions exchange their levels’ belonging, one of them from level 1 to level 2 and the other one from level 2 to level 1, Fig. 6. The distance is 4. The position of the third function is unchanged.

4.2 Distances Between Orderings Where All Functions Are Considered to Have Different Level of Helpfulness

The observed distances between two orderings where all hints are considered to have different level of helpfulness. Illustration details

From ordering (a(c(b))) to ordering (c(a(b)))
Both orderings have the same structure. Two of the functions exchange their levels’ belonging, one of them from level 1 to level 2 and the other one from level 2 to level 1, Fig 7. The distance is 2. The position of the third function is unchanged. The position
Figure 5: Elements $a, b, c$ have the same structure in both orderings.

Figure 6: Two the elements $a, b, c$ are changing levels of belonging within the same structure.

Figure 7: Two the elements $a, b, c$ are changing levels of belonging within the same structure of three different levels of helpfulness.

Figure 8: All elements $a, b, c$ are changing levels of belonging within the same structure of three different levels of helpfulness.

Figure 9: Two of the elements $a, b, c$ are changing levels of belonging within the same structure of three different levels of helpfulness.

of the third function is unchanged.

*From ordering $(a(c(b)))$ to ordering $(c(b(a)))*

All functions change their levels of belonging, Fig 8. The distance is 4.

*From ordering $(a(c(b)))$ to ordering $(b(c(a)))*

The first and the third functions exchange their levels of belonging, while the second function keeps the same level of belonging in both orderings, Fig 9. The distance is 6.

5 System Description

A system prototype is built as a Web-based application using Apache HTTP server mod_python module, and SQLite database. The mod_python module provides programmable runtime support to the HTTP server using Python programming language. The whole application components are Web-based users interface, application logic and application interfaces written in Python, and relational database.

The users, i.e. expert tutors, teachers, and students interact with the system using Web forms. Before any interaction with the system can take place, a user needs to be authenticated first. Experts and teachers can submit and update data, while students can only view information.

For a particular subject, an expert tutor will first submit data that will be used to construct a data table.
The system will then check that there are no duplicate attribute combinations and insert the context data into the database.

The system provides recommendations on whether or not a student needs to take additional classes (courses) based on fuzzy dependencies.

In this framework supporting personalized learning a new topic is recommended to a student (Fig. 10) after assessing his/her knowledge. The system responds to students’ needs according to their learning preferences and orientations.

6 Conclusion

Evaluating help functions based on students’ responses is more accurate than using questionnaires. Such an approach is not affected by subjective opinions and provides useful feedback to content developers.

The presented automated tutoring system is a response to the increased demand for the necessity of developing effective learning tools that can be smoothly integrated in the educational process.

The system uses each student’s diagnostic reports on miscalculations, misconceptions, and lack of knowledge and offers advice in the form of additional reading, hints and tests and recommends an interaction with the human tutor when needed.

References:


