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Developing an Intelligent Tutoring System for Palm Oil with ASPIRE

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Abstract: Although Intelligent Tutoring Systems (ITSs) have well proven their effectiveness in many learning domains, building them have always required extensive effort and time. ASPIRE authoring system has been used in developing constraint based tutors (CBTs) before but this will be the first attempt to develop a CBT and embed it within an existing system. We present the research and development of DM-Tutor, the first CBT to be embedded within the Management Information System (MIS) for palm oil plantation management. We discuss the research and development of DM-Tutor with the help of ASPIRE. We also include future work planned for DM-Tutor.

Keywords: authoring systems, intelligent tutoring systems, embedded constraint based tutor, DM-Tutor

Introduction

Intelligent Tutoring Systems (ITSs) have provided their effectiveness in increasing learning performance [3]. Over the years, ITSs have been used in various teaching and learning domains. SQL-Tutor [1] and KERMIT [5] are among the many successful constraint-based tutors (CBTs) developed and implemented. Our approach is to develop ITSs using ASPIRE [2], a complete authoring and deployment environment for constraint-based ITSs.

This paper describes the research and development stages of DM-Tutor (Decision-Making Tutor), an ITS for the palm oil domain. Although ASPIRE has been used to develop CBTs before, no previous attempt has ever been made to embed a CBT into an existing live operational system. This will be the main contribution of this paper. This paper is organized as follows. In the next section we describe DM-Tutor. Section two discusses the development of DM-Tutor with the help of ASPIRE. Section three describes conclusions and future work planned for DM-Tutor.

1. DM-Tutor

DM-Tutor is the first ITS to be developed for palm oil plantation management. The aim of DM-Tutor is to provide scenario-based decision making training on real life operational and management challenges for managers of palm oil plantations. DM-Tutor will be embedded within a Management Information System (MIS) [4] currently being used for the palm oil industry in Malaysia. With DM-Tutor embedded within the MIS, students will be presented with real-life management scenarios and would practice making operational analyses with actual plantation data. By practicing with real cases, students would acquire the necessary abilities for improving their decision making skills in the actual plantation management environment. DM-Tutor focuses on three main analyses that are of the biggest concern in palm oil plantation management: yield gap analysis, fertilizer management and yield forecasting.

2. Development of DM-Tutor

ASPIRE assists with the development and implementation of CBTs using a semi automatic process. The development of DM-Tutor is described in five main stages:

The first development step in DM-Tutor is identifying the most suitable pedagogical approach for this domain and the targeted students who would be using DM-Tutor. We modularized DM-Tutor into three tasks: Yield Gap Analysis, Fertilizer Analysis and Yield Forecasting. All the tasks in DM-Tutor are procedural, which means that problem solving has to be carried out in pre-ordered steps and that every step of the problem solving process is important and necessary in order to arrive at the correct solution. We specified all the problem solving steps using the Domain Details tab/window of ASPIRE. We provided additional information to provide clear task descriptions and problem specific instructions for each task.

In the second stage we developed domain ontology for each of the tasks in DM-Tutor using the ontology workspace in ASPIRE. Developing domain ontologies is crucial for the authoring process because it contributes to the building of syntax constraints. In the domain ontology we identified important concepts for each task in DM-Tutor and the relationship between these concepts using a hierarchical structure. A concept may be related to another concept through an *is-a* relationship and this is depicted by the arrows between concepts in the ontology workspace. By creating ontologies we were able to study the domain in greater detail and this enabled ASPIRE to organize constraints in a meaningful way to develop more accurate constraint bases.

In the third stage we modeled the problem and solution structures. DM-Tutor consists of procedural tasks, and each problem-solving step might require several solution components. We specified the problem steps for each task when we developed the domain details in stage 1. As mentioned previously, each solution component comes from the ontology for each task. For palm oil plantations, it is very important to ensure that the amount of fertilizer used in the estates is accurate and cost efficient. Partial Factor Productivity (PFP) and Agronomic Efficiency (AE) are two suitable techniques used to gauge fertilizer or nutrient efficiency that we have included in DM-Tutor. Fertilizer Management analysis in DM-Tutor consists of several problem solving steps. Steps 1 and 2 require students to select the correct formula to calculate PFP and AE so the student has to select the correct formula from the list of formulas available in the solution component. Step 3 of the problem requires the student to calculate PFP and AE for the estate and enter the correct value into DM-Tutor's interface. DM-Tutor will check student's answer in each step and also check to see if students accessed the relevant fertilizer consumption information from the MIS. If the student's solution for any step is incorrect, DM-Tutor will give increasing levels of feedback that would help guide the student to the correct solution before allowing her/him to proceed to the next step of problem solving.

In the fourth stage ASPIRE generated the default interface for DM-Tutor automatically, from the information provided in the solution structure and the ontology. DM-Tutor's student interface is divided into three parts. The top pane is where the problem statement is placed, so that students always know the problem they are attempting. The bottom pane presents the solution workspace where students need to work on their solutions to the problem and the side pane is used to provide feedback to the students on the problems they are attempting. The interface design for DM-Tutor is aimed at reducing memory load of the students. Currently DM-Tutor provides a textual interface where students are expected to provide text based input. DM-Tutor's tasks require students to access various reports and analyses of the MIS. This is necessary as the information required for solving problems in DM-Tutor comes from the MIS.

In the next stage ASPIRE generated constraints. Syntax constraints are generated by ASPIRE based on the domain ontologies we created earlier. The syntax constraint generation algorithm extracts all useful syntactic information from the ontology, such as the restrictions on concepts, properties and relationships with other concepts [6]. This is then translated into constraints. Each constraint checks that the relevance condition and satisfactory conditions of the constraint are not violated. Since DM-Tutor consists of procedural tasks ASPIRE created additional set of constraints called path constraints. This was necessary in order to ensure that problem solving occurs in the correct order. Semantic constraints are generated by ASPIRE based on the solutions we provided for each problem in DM-Tutor. Semantic constraints look for semantics or meaning based on errors in students' solutions enabling DM-Tutor to model alternative correct solution approaches.

3. Conclusions

In this paper we demonstrated how we developed DM-Tutor, an ITS for the palm oil domain with the help of ASPIRE, an authoring system that assists in the development and deployment of CBTs. Based on the domain characteristics we specified in DM-Tutor, ASPIRE was able to create the domain model for DM-Tutor. Developing ontologies by identifying concepts, their properties and the relationships between concepts was a very important step in the development of DM-Tutor as this enabled ASPIRE to generate constraints and an accurate constraint base as well. After ensuring that the information supplied for DM-Tutor was complete and consistent, DM-Tutor was successfully deployed as an ITS.

There are many potential research benefits in embedding ITSs with live systems and we hope to demonstrate that through our research. We have planned for DM-Tutor to be evaluated by users of different knowledge levels including students, trainee managers and managers in the palm oil industry. Upon completion of our research, we hope to demonstrate the potential of ITSs in increasing workplace training and efficiency.

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