

Teaching in Ill-Defined Domains Using ITS and AI Approaches

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Abstract: Ill-defined domains offer many challenges to computer scientists. Developing intelligent tutoring systems (ITSs) in these domains is a very challenging task due to the difficulty in modeling these domains, answers to ill-defined problems are ambiguously identified as right or wrong, and no generally accepted architecture is currently existed. This paper presents general guidelines for the development of ITSs in ill-defined domains, such as Argumentation and Ethics. This is instantiated in the two example systems AEINS and ALES. These systems offer adaptive learning processes and personalized feedback aiming to transfer the required skills to the learners and develop their reasoning.

Keywords: Ill-defined domains, argumentation, ethics, intelligent tutoring systems

Introduction

Problems around us can be classified as either well-defined or ill-defined. Well-defined problems are characterized by having a clearly defined domain structure that can be modeled. The well accepted models of these domains make it easy to unambiguously classify problem solutions as correct or incorrect. On the other hand, we consider problems that lack these characteristics, ill defined; there is no single right or wrong answer to cases nominally of the same type. In addition, learning in these domains is a case of change in the way a person thinks, and not is just of acquiring more knowledge.

Although many Intelligent Tutoring System (ITS) strategies have been employed in ill-defined domains and have proven successful in past studies [1], no generally accepted architecture is there yet. This can be contributed to the fact that various ill-defined domains differ in themselves and consequently require different kinds of representation and modeling and also may need different techniques in order to allow tracking the learner and providing personalized feedback.

In this paper, we present general guidelines for the development of intelligent tutoring systems in the ethics and argumentation domains instantiated in the two example systems AEINS and ALES. The paper focuses on the approaches each of the systems use in order to tackle the challenges present in the ethics and the argumentation domains, such as knowledge representation, tracking the learning process, and providing personalized feedback. Also how other ill-defined domains can benefit from the presented systems.

1. Developed Systems (AEINS and ALES)

Ethics is an important ill-defined domain; the development of skills of participation and responsible action is a fundamental part of the citizenship curriculum. Teaching ethics usually takes place through involving learners in moral dilemmas [2]. Taking this idea forward, an architecture has been designed that integrates intelligent tutoring and AI techniques (interactive narrative) in order to teach in the ethics domain, see fig.1. The architecture consists of two levels; *the tutoring level* aims to interact with the learner based on an understanding of the learner's behavior, and to provide an adaptive learning process.

The narrative level aims to generate story at run time that includes tacit educational information.

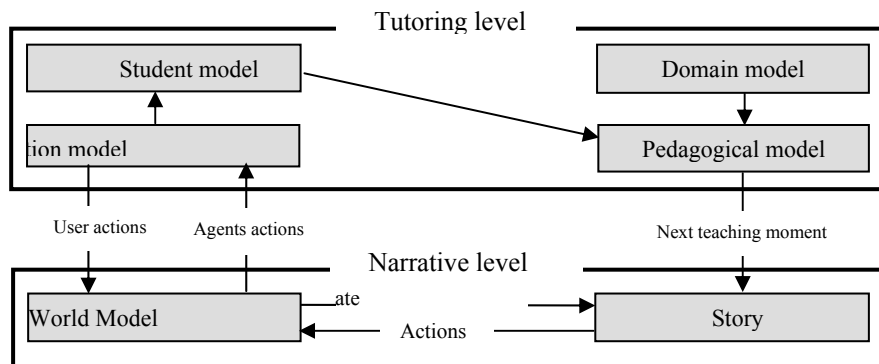


Fig.1: An architecture that integrates intelligent tutoring and interactive narrative

Based on the above architecture, an adaptive educational interactive narrative system, AEINS, has been implemented [3]. The idea is to transform analyzed moral dilemmas to story graph structures and to specify the decision points that reflect certain skills. AEINS provides a learning environment that helps 8-12 year old children to be engaged effectively in moral dilemmas (teaching moments) that accommodate the Socratic Dialogue as the teaching pedagogy because of its capability of forcing the learner to face the contradictions present in any course of action that is not based on principles of justice or fairness and model their own behavior. In so doing it is believed that learners will better understand the nuances of the domain. AEINS main aim is to allow learners to move from the “making moral judgments” state to the “taking moral actions” state, from the knowing state to the doing state, which we consider a very important step in moral education.

Another system is ALES that targets the argumentation domain. Argumentation is an ill-defined domain that connotes a typical lack of clear distinctions between "right" and "wrong" argument diagrams. Humans' knowledge and wisdom produced usually have the form of arguments that are built up from more primitive knowledge in the form of facts and rules. Those repositories or treasuries of knowledge are now about to be organized, by different trials [4], to argument data bases or corpora that can be retrieved, stored, and reused freely. Founded on the importance of argumentation skills in our life, an architecture has been designed upon which ALES system has been implemented in order to teach in the argumentation domain, see fig.2.

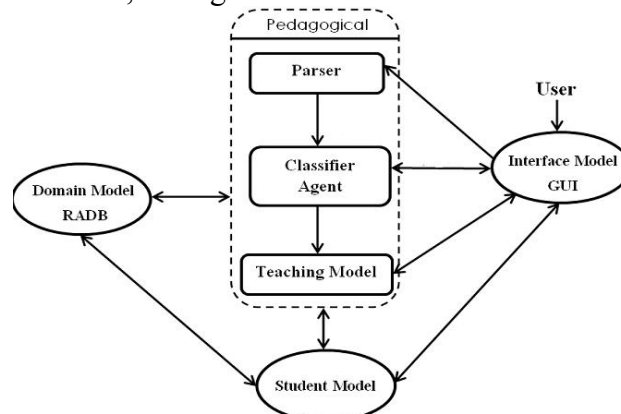


Fig.2: ALES architecture

ALES is an argument learning environment that uses different mining techniques to manage a highly structured arguments repository aiming to: i) offer an argument classifier agent that retrieves the most relevant results to the subject of search, ii) guide the learner during argument learning, iii) aid in improving the learner’s argumentation skills. The idea is based on utilizing the Argumentation Interchange Format Ontology (AIF) [4, 5] using

"Walton Theory" to help learners hone their argumentation skill. ALES contains learning and assessment phases. It uses mining agent-based ITS for teaching argument analysis, assessing the learner and guiding him through personalized feedback. It controls the "RADB" repository [6, 7] to expose expert knowledge.

2. Intelligent Tutoring

2.1 Domain Model

The domain model in both systems, AEINS and ALES, has been designed according to the nature of the tackled domains. Both models enjoy the extendibility feature and are general enough to encapsulate multiple domains. In AEINS, The domain model is represented in the form of frames that describes the various concepts (values) in the ethics domain and their relationships and dependencies. Frames representation provides partial ordering of the educational concepts. Another part of the domain model is constructed in the form of a repertoire of moral dilemmas (teaching moments). The domain structure and an example of a teaching moment can be found in [3].

In ALES, The domain model is represented in the form of a relational argument database (RADB) [7]. The database contains arguments that were previously analyzed by experts based on Walton theory using the AIF ontology [5]. The domain model can semantically be represented as a forest of a numerous directed free trees [11]. This structure mainly aims to provide a myriad of arguments at the user's fingertips, and support the fast interaction between the different mining techniques and the existing arguments.

2.2 Student Model

The student model is a crucial component in any ITS system that mainly aims to provide adaptation; it involves creating an individual model for every learner. In AEINS, the student model is an overlay model represented in the form of rules associated with confidence factors [3]. Rules representation is effective in building and updating a model of the student's learning process at run time. In ALES, The student model stores details about learner's current problem-solving state and long term knowledge progress, that is essential for future learner's performance evaluations. The model considers personal information, pre-test evaluation, and performance history.

2.3 Pedagogical Model

The pedagogical model is responsible for reasoning about the learner behavior according to the current student model. In AEINS, the pedagogical model is developed in the form of production rules that are used to give the system specific cognitive operations to reason about the learner and the teaching process. The use of rules enables assessing the learner's actions easily at run time. In ALES, the pedagogical model, see fig.2, consists of three components: a parser that improves the results and reduces the number of iterations done by the classifier agent, a classifier agent that mines the RADB repository [7], a teaching model that monitors, guides the learning process and provides personalized feedback.

2.4 Presentation Model

The presentation model offers a GUI that controls the flow of information and monitors the interactions between the user and the system and vice versa.

3. AI Techniques

AEINS used AI planning to generate interactive narrative in which the learner is an active participant; his actions affects the story unfolds. Because of the freedom provided in this technique, tracking the learner and assessing his actions by the intelligent tutor become a very difficult task, if not impossible. AEINS uses branched graphs to represent the dilemmas as a solution in order to constrain the learner's actions and in turn preserves the educational goals. AEINS also uses semi-autonomous AI agents who inhabit the environment. Each AI agent is implemented as a set of rules, saved in the world model, that describe the agent personality and control its behavior.

ALES uses different mining techniques in the learning phase in order to achieve the pedagogical model aims. For example the priority search uses an adapted version of the AprioriTid mining technique to mine the pre-existing arguments based on learner's specifications. ALES exploits the tree structure of the RADB using breadth first search in order to encounter all nodes in the different argument trees and to retrieve the most relevant group. ALES also offers the rule extraction search that discovers all the embedded sub-trees [7] and provides the learner with the most relevant arguments relative to his search.

4. Feedback and Assessment

Adaptation and feedback are the main advantages of intelligent tutoring systems. Due to the nature of the ethics domain and the targeted learners' age, feedback is implicitly provided in AEINS using the Socratic Method in the narrative context of the teaching moments. The Socrates' voice is adopted by one of the agents who tries to guide the learner in order to find out any kind of discourse existed in his unethical actions. AEINS also provides final commulative feedback that provides evidence for a cause-and-effect relationship and helps the student or the teacher to reason about the whole learning process.

ALES provides two types of explicit feedback: *formative feedback* carried out throughout the analysis process node by node. The system provides partial hints at each node of the analysis tree as a result of comparing the learner's current node analysis to the original one in the argument database. This kind of feedback is very important as it recognizes the learner's gaps and misconceptions and deals with them instantly. *Summative feedback* is also provided by the system at the end of the analysis process. This kind of feedback is useful as it assesses long term effects and provides data on change across time.

During the learning phase the system traces the learner's actions by storing the accessed arguments, number of accessing ...etc. This information is used later to control the assessment phase; the arguments in this phase are the arguments that have not been accessed during the learning phase by the learner. ALES is also able to generate different types of representative reports about the learner's analysis history, which shows the learner progress and in turn excavate the proper weakness points in the learners' analysis skills.

Analytical evaluation for both systems has been done through intrinsic evaluation that checks the implicit goals embodied by aspects of the design, and makes value judgment about these goals. It has been found that the rule representation currently used allows the appropriate level of interaction between the modules. Most importantly is the systems' ability to correctly identify the participants' misconceptions and provide the suitable feedback, for instance the pedagogical models are able to decide about the next appropriate educational step based on the current student model, where the presence of the

student model allows the required personalized learning process according to the learner's needs. On the other hand, without such model, the teaching scenario is presented in a specified sequence for all learners whatever the differences between them. With this evidence, we can say that the systems' modules are able to fulfill the design aims. In the future, empirical evaluation is planned to assess the educational outcomes of the systems.

5. Related Work

Many narrative-based educational systems work on balancing try to balance the evolved narrative and the education process by tailoring the educational materials in the narrative. Some systems exhibit narrative limitations for example, ELECT BiLAT [12] and BAT ILE [13]. Other systems lack the presence of a student model such as Crystal Island [14] and FearNot! [15], others exhibit unclear effect of the learner's actions on the learning process as in Mimesis [16] and TLCTS [17]. AEINS has been developed to tackle these shortcomings.

Recently, in argumentation field, a number of argument mapping tools [18] have been developed. However, personalized guidance to the student is missing. Trials have been done in order to overcome this, for example the ArgDf system [5]. The ArgDf system guides the user during the creation process based on the scheme structure, and searches the existing arguments by specifying text in the premises or the conclusion, as well as the type of relationship between them. Whereas ALES offers crucial hints through two types of feedbacks and provides different strategies based on different mining techniques.

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