# Application of Default Logic in an Intelligent Tutoring System

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**Abstract.** Default logic is often used for solving knowledge representation problems in a compact, robust and flexible way. One of goals of intelligent systems is to provide efficient evaluation students' responces. Often they operate only 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. In this paper we propose use of default logic in an intelligent tutoring system as a way of resolving the problem with inconsistent and/or incomplete input.

**Keywords:** Knowledge assessment, learning, logic.

## 1 Introduction

The issue of rewarding partially correct answers has been addressed by many authors. 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' responces 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. In this paper we propose use of default logic in an intelligent tutoring system as a way of resolving the problem with inconsistent and/or incomplete input.

The rest of the paper is organized as follows. Related work and statements from default logic may be found in Section 2. The main results of the paper are placed in Section 3. The system architecture is described in Section 4. The paper ends with a conclusion in Section 5.

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## 2 Background

Default theory was first introduced in [10]. Distinction between definite consequences and default consequences was first discussed in [1]. Ten-valued logic was used in [12] and [13] to order default theories and distinguish different sorts of information. Ten-valued logic composed of four basic and six composed values was applied in [16] for performing implication, justification, and propagation in combinatorial circuits.

A level-based instruction model is proposed in [7]. A model for student knowledge diagnosis through adaptive testing is presented in [3]. An approach for integrating intelligent agents, user models, and automatic content categorization in a virtual environment is presented in [14]. Previous research indicates that interactive-engagement classes can achieve at higher levels than more didactic classes, and that students in active-engagement computer-based physics classes outperform students who receive traditional instruction [4].

The Questionmark system [5] 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 responce can be correct, incorrect, partly correct or partly incorrect. The final outcome is correct or incorrect because the system is based on Boolean logic [2], [19].

A default theory is a pair $\Delta = (D, W)$ where $D$ is a set of default rules and $W$ is a set of quantifier-free formulas [10]. A set $S$ of formulas is deductively closed if $S = Th(S)$, where $Th$ is the usual deductive closure operator. A set $E$ of formulas is an extension of $\Delta$ if it coinsides with the smallest deductively closed set $E'$ of formulas satisfying the conditions:

- $W \subseteq E'$,
- $\forall \alpha : \beta_1, \beta_2, ..., \beta_n / \gamma \in D, \alpha \in E', \neg\beta_i \notin E, i = 1, .., n$ implies $\gamma \in E'$.

A formula derived from a theory is either a definite consequence by $W$ or a default consequence by $D$. A formula is

- a credulous conclusion of $\Delta$ if it belongs to some (but not all) extensions, and
- a skeptical conclusion of $\Delta$ if it belongs to all extensions.

Default consequences are results of two modes of inferences - skeptical or credulous reasoning. The logic used here for default reasoning has the following truth values:

- $t$ - true
- $f$ - false
- $\perp$ - undefined
- $\top$ - contradictory
- $d\top$ - contradictory by default