Chapter 13
An Intelligent System for Learning First Order Logic to Clause Form Conversion

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ABSTRACT

In this chapter, the authors present an intelligent Web-based interactive system that aims at helping students in learning to convert First Order Logic (FOL) sentences into their Clause Form (CF) and provides feedback based on the student’s actions. The system provides a step-by-step guidance and help during that process. It adapts its interface to the current step requirements. In addition, feedback is provided to the user-student upon request. The feedback is based on the errors made, which are detected by the system and classified in predefined categories. The system offers to the students the capability of trying the conversion of any FOL sentence of their own or choosing any of the pre-stored ones. The authors evaluated the system using two groups of undergraduate students (an experimental group and a control group). During the experiment, a pre-test and a post-test were used by both groups to collect the data. In addition, a questionnaire was given to the experimental group. Results are encouraging in that they revealed significantly better performance of the experimental group. Furthermore, the questionnaire results, concerning the system’s usability and learning capabilities, have been quite satisfactory.

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INTRODUCTION

The advent of the Web has changed the way that educational material and learning procedures are constructed and delivered to the students. It provides a new platform that connects students with educational resources, which is growing rapidly worldwide giving new possibilities to students and tutors and offering better, cheaper and more efficient learning processes. Web based education systems are becoming a fundamental mean of education delivery. Indeed, nowadays more and more universities and educational institutes develop and use web based educational systems to assist not only students in learning but also tutors in managing courses to the best advantage of the students. The teacher’s role is also changing and is moving from the face-to-face knowledge transmission agent to the specialist who designs the course and guides and supervises the student’s learning process (Huertas 2007). Web-based intelligent learning has become more effective in the past decade due to increasing use of the Internet in education. Also, such systems have been used in many disciplines in education and have demonstrated remarkable success in helping students learn challenging contents (Patil et al 2010).

Logic is considered to be an important domain for the students to learn, but also a very hard domain to master. Many tutors acknowledge that a course about Logic and Artificial Intelligence (AI) contains complex topics, which are difficult for the students to grasp. Knowledge Representation & Reasoning (KR&R) is a fundamental topic of such a course. A basic KR language is First-Order Logic (FOL), the main representative of logic-based representation languages, which is part of almost any introductory AI course and textbook. To make automated inferences, Clause Form (CF), a special form of FOL, is used. Students find difficulties in various aspects of using FOL as a knowledge representation and reasoning language. Two of them are (a) converting natural language (NL) sentences into FOL formulas and (b) converting complex FOL formulas into CF (Hatzilygeroudis 2007; Hatzilygeroudis et al 2004). There is a systematic way to convert FOL formulas into CF (see Section 3), which we call the FOLtoCF process.

Learning to use FOL as a KR&R language is considered to be a hard, cognitively complex and error prone process for the students. It is difficult to deeply understand and implement related processes. We have constructed tools for helping students in learning and tutors in teaching logic as a KR&R language. More specifically, we introduced an intelligent tutoring system for learning (or teaching) the conversion of NL sentences into FOL ones (Hatzilygeroudis et al 2009; Perikos et al 2011a; Perikos et al 2011b).

In this chapter, we deal with teaching the FOLtoCF process, using a web-based interactive system that helps students to learn the conversion process. The system provides a step-by-step guidance and help during learning process. We developed a hint generation mechanism that is used to generate and provide proper feedback and guidance in accomplishing each step of the FOLtoCF conversion. This is based on a mechanism that is used to recognize and categorize the type of the error(s) made by the student during learning sessions. To assess the effectiveness of our system, an extended evaluation study was conducted. Two groups of undergraduate students (a control and an experimental) and a pre-test and post-test evaluation methodology were used to evaluate system’s effectiveness in learning the FOLtoCF process. This chapter is an extended of (Grivokostopoulou et al 2012a).

The chapter is organized as follows. In Section 2 related work is presented. Section 3 deals with the FOL to CF conversion, by presenting the FOL syntax and the conversion process through an example. Section 4 presents the system architecture and analyzes its functionality. Section 5 presents the intelligent unit of the system used to recognize students’ errors and provide proper feedback. Section 6 describes the student interac-