An Intelligent Problem Solving Environment in the Domain of Electrical Engineering

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Abstract. This paper presents mileET - an intelligent problem solving environment (IPSE) for a topic area from the basics of general electrical engineering. MileET supports the learner throughout the whole process of problem solving. Our work is based on cognitive science research (ISP-DL[1]-Theory [1]) of our group and on the development of IPSEs in various domains [1, 2] as well as on the competence of the partner universities in general electrical engineering and on their elaborated task collections. As no formal specification of the tasks exists, we classified the tasks according to their informal specified goals and elaborated a new model (called Y-Model) describing the process of domain specific task solving. This model is implemented in Prolog as a set of goal-mean-relations (GMRs) [3], and allows an elaboration of the planning objectives and symbolic computation. These GMRs form the core of our generative expert system (GXPS) that provides the adaptive support while solving tasks.

Keywords. Intelligent problem solving environments, adaptive hypotheses testing, electrical engineering education, models of tasks, knowledge representation, cognitive diagnosis, adaptive environments

Introduction

Most of the e-learning developments in the domain of electrical engineering have an instructional character. Even if they contain tasks the learner has to solve they don't analyse steps of the solution path or incomplete solution proposals. So situation-adapted help can't be given if the user is in an impasse while solving a task. Other programs used by students, like computer algebra systems (CAS) and professional circuit editors, can't analyse if equations or circuits belong to the solution for a given task. As both circuits and equations build the solution of most of our tasks an environment with editors for circuits and formulas is demanded.

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[1] Impasse-Success-Problem-Solving-Driven-Learning

IPSEs [1] belong to the class of constructivistic learning environments. They enable students to solve domain relevant tasks. During problem solving the learner can demand adaptive help created by a GXPS. This GXPS is able to analyse the solution proposals and it is therefore able to respond adaptively to student hypotheses.

The mileET tasks are taken from task collections of the partner universities and will be saved in the TaskWeb-Database [4].

1. Knowledge Representation and Hypotheses Testing

After detailed analysis of the task collections the Y-Model for the representation of the process of domain specific task solving was elaborated. Any supported task can be understood as relation over the sets of circuits (C), parameters (P), mathematical descriptions (M), and domain concepts (CF). The circuit topology information is stored in the C-set, symbolic and numeric parameter in the P-set, and mathematical equations in the M-set. According to a task goal several Y-Types of our tasks can be built. Mathematical equations, parameters and circuits – parts of all these sets may be a task's goals. These sets P, C, and M can be derived from each other by application of CF. For example, by application of the Kirchhoff's laws on a given network the KCL equations can be obtained. This derivation represents the task solving process of an expert and can be produced by our IPSE by means of goals-means-relations (GMR) .

Owing to GMRs and to a special GMR-Meta-Interpreter the system will be able to examine hypotheses of the students, and to possibly complete solution proposals, too. GMRs assign the means (solutions) to the goals (tasks and subtasks). In our IPSE all means are parts of the three sets (C), (P) and (M) of the former described Y-model. As our GMR-rules are very fine-grained they can be combined to get a very large set of different solutions, containing also "unusual" ones.

2. Working Environment and Hypotheses Testing

The working environment (figures 1, 2) consists of several scalable areas, here shown in a very minimized way.
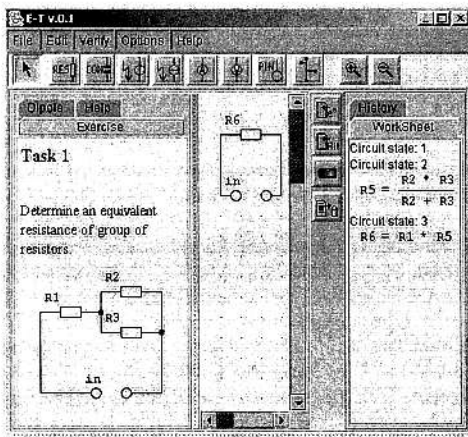

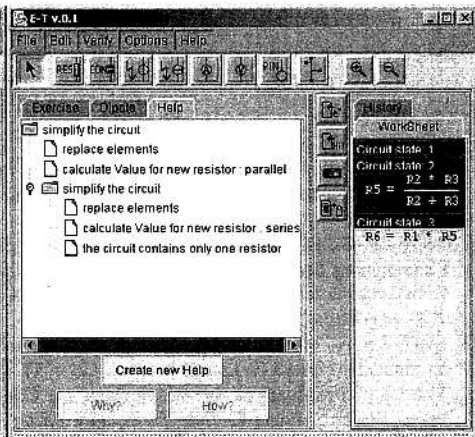**Figure 1.** Incorrect Proposal   **Figure 2.** Embeddable Hypothesis and Adaptive Help

In the task area (figure 1, left) the task settings and the information about circuit elements are shown. In the middle of the window the circuit editor is located, where the student can work on the task's circuit (set or change the properties of circuit elements, transform or simplify the circuit). On the right side there is the worksheet area. It contains the solution proposal of the student. If the learner thinks the circuit he has edited belongs to the task solution, he can copy it into the worksheet. He also can write formulas with a special implemented formula editor. The system's feedback can be seen at the bottom of the window or in a message window.

The learner may ask the system for an evaluation by marking his proposal even if it is incomplete. To prove the correctness of the proposal the system tries to embed it in a dynamically generated solution. In case of an incorrect solution proposal the system gives error feedback. Now the user has to formulate a new hypothesis by marking the parts of his proposal which he assumes to be correct. The system gives positive feedback only if the hypothesis can be embedded in a correct solution. In this case the solution trace of the program can be requested by the student (figure 2) for getting help how to complete his proposal. If the student lacks declarative knowledge, he can start the web-based learning modules of the partner universities. The appropriate links will be offered in the help window.

3. Conclusion

Our learning environment is meant for beginners who do not have enough experience with the professional software packages such as CircuitMaker or Mathematica, and who need support by solving tasks. The problem solving environment is adapted to the tasks of our partner universities. It can be used to solve different other tasks, too, as long as these tasks lie within the predefined topic fields. At the present tasks e.g. to such topics like basic electrical circuits, Kirchhoff's laws, equivalent circuits are supported. Further on, the working environment can be used task-independently. The student may use the system as an experimental work environment and explore any circuit from the knowledge domain implemented in the system.

Our learning environment can be used both in direct study and for self learning. System explanations and commented solutions are helpful during preparation for examination. Comprehensive testing and evaluation of our IPSE will take place at our partner universities after completion of the first prototype.

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