DESIGNING A RESOURCE-EFFICIENT EXPERT SYSTEM

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Introduction

The task of electric drive troubleshooting is one of the most topical problems in diagnostics at present. One of the obstacles is the absence of a comprehensive system for the fault coverage of electric drives. Attempts to create such a system are unknown to scientific community, if were made at all. In this paper, the problems associated with prototyping such an expert system are considered.

Resource Efficiency

Nearly all spacecrafts designed at Russian engineering bureaus and scientific establishments are equipped with aerials for communication and solar batteries for the acquisition and transformation of solar energy into electrical as well as other kinds of energy. The task to develop an expert system, i.e. a program for the troubleshooting of such objects is unconventional and, in the general case, is complicated by the lack of antecedent information on object tests and their kinds, on the sequence of tests and, last but not least, on possible faults. This shortcoming is compensated by means of knowledge engineering, i.e. the acquisition of knowledge concerning the mentioned tests from the experts on diagnosis who are currently working at scientific establishments. Afterwards, the most typical approach is to create and introduce an expert system capable of accumulating the knowledge of experts and drawing conclusions on the grounds of a certain set of condition-action rules, which is often defined in terms of fuzzy logic. At this stage, the system for the mentioned kinds of diagnosis has already been created and is functioning as an effective prototype.

The benefits of the system in terms of resource efficiency can most evidently be divided into three main categories:

1. First of all, the creation of an expert system allows of optimizing the labour and efforts of the engineers who test precise electric drivers for spacecrafts. According to [1], time is an irreplaceable nonmaterial resource; in much the same way, the availability of such a system lowers the material expenditures (money, materials, assets) needed for different tests. According to the same source of information, the system under study is intended to transfer from the human intellectual capital into the organizational one, which cannot be lost, moreover, the latter can be expanded by adding new production rules to the existing system.
2. Secondly, using sunlight as a source of energy is one of the promising directions in the development of energetics, according to [2]. Sunlight is a material inexhaustible resource of the Earth and space, and, thereby, its usage as a source of energy is justified and leads to benefits in resource efficiency. Moreover, without such a system, in case one electric driver fails, the spacecraft launches additional batteries, and if they become faulty, it stops functioning and performing its duties, which may harm resource efficiency on a global scale.
3. Besides the fact that the first two mentioned factors lead to decreases in contamination levels and the overcoming of the problem of resource depletion, the software product is an information inexhaustible resource per se, the creation of which leads to the economy of financial resources.

Knowledge Acquisition

In order to acquire such resource efficiency, a research group first needs to develop an expert system. Steps in the expert systems development process include determining the actual requirements, knowledge acquisition, constructing expert system components, implementing results, and formulating a procedure for maintenance and review.

Knowledge acquisition is the most important element in the development of expert system [3]. Knowledge could be obtained by interviewing domain experts and/or learning by experience. Very often people express knowledge as natural language (spoken language), or using letters or symbolic terms. There are several methods to extract human knowledge. Cognitive Work Analysis (CWA, fig. 1) and the Cognitive Task Analysis (CTA) provide frameworks to extract knowledge.

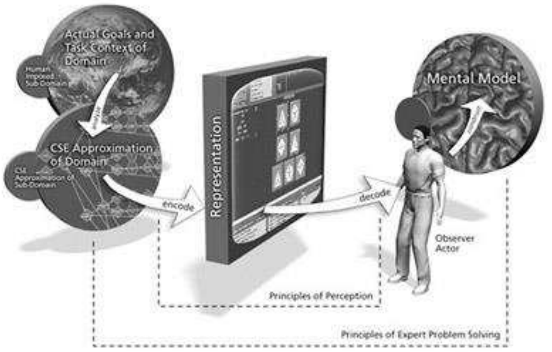

Fig. 1. Cognitive Work Analysis

The CWA is a technique to analyze, design, and evaluate the human computer interactive systems [4].

The CTA (fig. 2) is a method to identify cognitive skill, mental demands, and needs to perform task proficiency [5]. This focuses on describing the representation of the cognitive elements that defines goal generation and decision-making. It is a reliable method for extracting human knowledge because it is based on the observations or an interview.

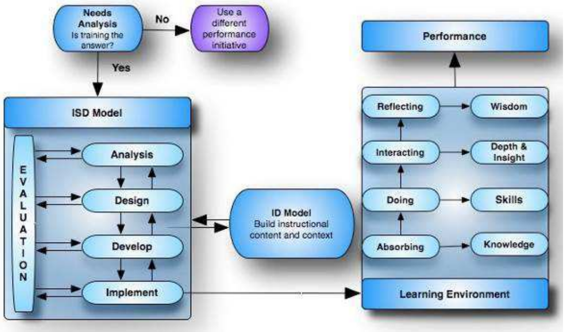

Fig. 2. CTA illustrated

Most expert systems are developed using specialized software tools called shells. These shells come equipped with an inference mechanism (backward chaining, forward chaining, or both), and require knowledge to be entered according to a specified format. One of the most popular shells widely used throughout the government, industry, and academia is the CLIPS [6]. CLIPS is an expert system tool that provides a complete environment for the construction of rule- and/or object-based expert systems. CLIPS provides a cohesive tool for handling a wide variety of knowledge with support for three different programming paradigms: rule-based, object-oriented, and procedural. CLIPS (fig. 3) is written in C for portability and speed and has been installed on many different operating systems without code changes.

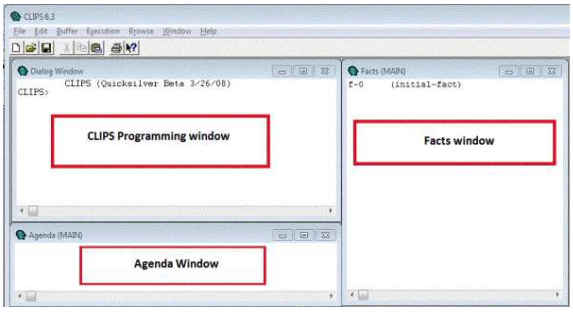

Fig. 3. The main window of CLIPS

Ways of Implementation

Expert knowledge is often the main source to design the fuzzy expert systems. According to the performance measure of the problem environment, the membership functions, rule bases, and the inference mechanism are usually to be adapted.

Neural network learning, self-organizing maps and clustering methods could be used to generate rules. Gradient descent and its variants could be applied to finetune the parameters of parameterized input/output membership functions and fuzzy operators [7].

Adaptation of fuzzy inference systems using evolutionary computation techniques has been widely explored. Evolutionary Computation (EC) is a population based adaptive method, which may be used to solve optimization problems, based on the genetic processes of biological organisms [8]. The second method (Pittsburgh approach), evolves a population of knowledge bases rather than individual fuzzy rules. Reproduction operators serve to provide a new combination of rules and new rules.

The third method (Iterative Rule Learning (IRL) approach), is very much similar to the first method with each chromosome representing a single rule, but contrary to the Michigan approach, only the best individual is considered to form part of the solution, discarding the remaining chromosomes of the population. The evolutionary learning process builds up the complete rule base through an iterative learning process [9].

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