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KNOWLEDGE BASESYSTEM DESIGN FOR DIAGNOSIS OF COMPUTER COMPONENTS USING FLOWCHART

Krivoulya G.F., Shcherbak V. K.

ПРОЕКТУВАННЯ БАЗИ ЗНАНЬ ДЛЯ ДІАГНОСТИКИ КОМП'ЮТЕРНИХ КОМПОНЕНТІВ З ВИКОРИСТАННЯМ БЛОК – СХЕМ

Кривуля Г.Ф., Щербак В. К.

In this paper is proposed the procedure a knowledge base designing for computer components diagnosis using flowcharts and Bayes method. The intelligent expert system automates the process of maintenance, repair, and relieves technical staff from manual execution of routine, time-consuming tasks for maintenance of computer components. The expert system detects various hardware malfunctions, as well as gives recommendations for their possible correction. Production rules of the proposed expert system are in the form of operations if-then. An expert system conducts a dialogue with the user, receives facts about the problem and asks questions in the process of user consultation with the system. During the consultation, questions appear on the computer's display screen; the user answers by storing the answers or important data. An expert system prepares a response to the user using the Bayesian method and the diagnostic knowledge base. Applying the results of the expert system with the probability of a malfunction for each outcome allows you to optimize the procedure for diagnosing the computer hardware components.
Keywords: *diagnosis, knowledge based system, expert system, flowchart, Bayesian method*

Introduction. Today, computer systems are used in many areas of science and technology and the demand for reliable operation of computers is increasing. Computer systems continue to become more complex and many users face computer problems due to the difficulties of diagnosing a possible malfunction in the computer hardware or software. Hardware malfunctions are the most difficult because it affects our daily life and our work. Extensive use of computers makes computer maintenance a problem that cannot be ignored and needs to be solved. It is recommended to use expert systems to diagnose hardware failures. An expert system is a computer program that can perform at the level of a human expert in a specific problem area, such as hardware or software problems. Expert systems are knowledge-based systems that mimic a chain of reasoning by an expert in a particular problem area or clarify uncertainties when it is usually necessary to consult one or more human experts. Expert systems not only help us, but also act as an intelligent person, full of knowledge, and give us advice in many areas where it is impossible to get many people to do the same. The main goal of the expert system is to provide a solution to the problem, when necessary, sometimes in a matter of seconds this use. Expert systems thanks to their knowledge can make accurate and fast decisions and can assist all professionals and users.

The use of expert diagnostic system with good knowledge base provides support for decisions in situations for which the diagnosis algorithm is not known and is formed from the initial data in the form of production rules. To automate the process of accumulation of knowledge in an expert system, it is advisable to use flowchart of the computer components.

Statement of the problem. Each part of the computer system has its own troubleshooting mechanisms to ensure its integrity at the time of the problem in the computer system. There is a limited amount of troubleshooting resources and standardized service strategies to determine the problem of computer component at the general level or at a special level of maintenance. The detection of one or more problems that arise in the computer component is a challenge for technicians. Professionals use this limited number of troubleshooting resources to specifically support the problem of computer components, since this solution is not a simple task for a technical worker. Solving the problem of a limited number of troubleshooting resources and maintaining the technical expertise of expert systems is critical. Using an intelligent expert system reduces the time and cost of troubleshooting and repairing errors.

Resent Publications. The expert diagnostic system is suggested to be used for the analysis of the computer system's technical state [1, 2, 3]. The causes of computer hardware failure are summarized and the specific maintenance methods are provided for diagnosing the computer hardware failures [2]. An expert system is introduced to develop hardware for fault-detection for any computer system with many types of computer faults and it is divided into different problem modules [3]. The mathematical apparatus that allows operating the expert assessment of the diagnosis object's state (hardware, software or staff) is fuzzy logic. In the preparation stage of the diagnostic experiment it is proposed to describe the diagnostic features of the computer system in terms of linguistic variables, which makes it possible to use the knowledge and experience of the expert in their familiar form [1]. The disadvantage of modern monitoring systems in the diagnosis of complex technical objects is the inability to determine the initial stage of a failure diagnosis object. The introduction of modern intelligent technology in solving problems of diagnosis can not only compare the monitored parameters with their reference values, but also to predict the possibility of determining the initial stage of malfunctions in the form of failures, both individual elements and the object as a whole [4]. Expert system is a computer program capable of performing at the level of a human expert in a specific problematic area such as computer hardware failures [5]. An expert system was designed to model the behaviour of an expert in some fields and use the same rules the expert would use to draw conclusions from a set of facts that are presented to the system [6]. Diagnosis Expert System using Bayesian Networks is system developed to help patients and non-patients to diagnose common adult diseases based on the given symptoms. This application uses Bayesian Networks in diagnosing the diseases [7]. The functional diagnosis expert system based on knowledge base in the form of neuro-fuzzy network was proposed in this paper. Current values of diagnostic parameters are measured by sensors. The hybrid expert diagnostic system with neuro-fuzzy network knowledge base supports decisions in the situation when the diagnosis algorithm is not known and is formed from the initial data in the form of production rules [8]. The using flowcharts and decision trees for computer component diagnosis are described in [9, 10].

Thus, in determining the technical condition of the complex technical facilities (computer systems) major critical factor is the time of the decision to localize faults. The use of expert diagnostic system with knowledge base provides support for decisions in situations for which the diagnosis algorithm is not known and is formed from the initial data in the form of production rules. To automate the process of accumulation of knowledge in an expert system, it is advisable to use flowcharts of the technical object. From the analysis of articles follows focus on developing the knowledge base as the main part of the diagnosis expert system.

The purpose of the paper is to describe the knowledge base system designed for the diagnosis of computer components using flowcharts and decision trees.

The using flowchart and decision tree for diagnosis of computer components. This part of article presents computer hardware faults and troubleshooting with repair flowcharts [10]. Troubleshooting is applied to computer component that has suddenly stopped working. It is previously working state forms the expectations about its continued behavior. A basic principle in problem analysis is to start from the most probable possible problems first. A troubleshooter using flowchart could check each component in a computer one by one, substituting known good computer components for each suspect one. This consistent process can be considered on the stage when components are substituted without regard to a hypothesis concerning how their breakdown could result in the symptoms being diagnosed. Simple and intermediate items can be easily represented by trees of dependencies among their components or subsystems. Technical documentation produced by proficient engineers and experts is very helpful, especially when it provides a theory of operation for the targeted device of computer system. Troubleshooting can also prepare the systematic checklist, troubleshooting procedure, flowchart or table that is made before a problem occurs.

Developing troubleshooting procedures in advance allows in organizing the diagnostic failure seeking into the most efficient fault diagnosing process. Fault diagnosing tables can be calculated to make them more efficient for users. Some computerized fault diagnosing services immediately show all available solutions with the highest probability of fixing the issue. The technician can either answer additional questions to advance through the fault seeking procedure or immediately implement the solution they think will fix the malfunction.

We use the following flowchart (Fig. 1) to build our expert system. To solve the problems that occur in the Power Supply PC we have created the meant expert system by keeping a track of the chart. In brief, the previous flowchart shows the way to provide the appropriate solution.

Morris Rosenthal in [10] describes how to find a power supply failure using flowchart: "Check power comes on, then we check if there isn't live screen, we proceed to video failure hart, if we get live screen, we will have new build, then we check power requirement vs rating. But if power doesn't come on, then if there isn't good AC power source, we use live outlet. If there isn't new build, we will try again to boot on we get premature power ok signal. Try different power supply. If it doesn't boot on, we check if we hear any beeps, then we proceed to motherboard failure chart, if there aren't any beeps, we need to install new hardware and remove latest addition and retry. Test replace power supply if there is a good AC power source, we check if 110/220V is set, then select proper voltage on near of power supply if 110/220 V is set, then we check, if motherboard lead isn't installed, we check manual and motherboard silkscreen …" and so on.

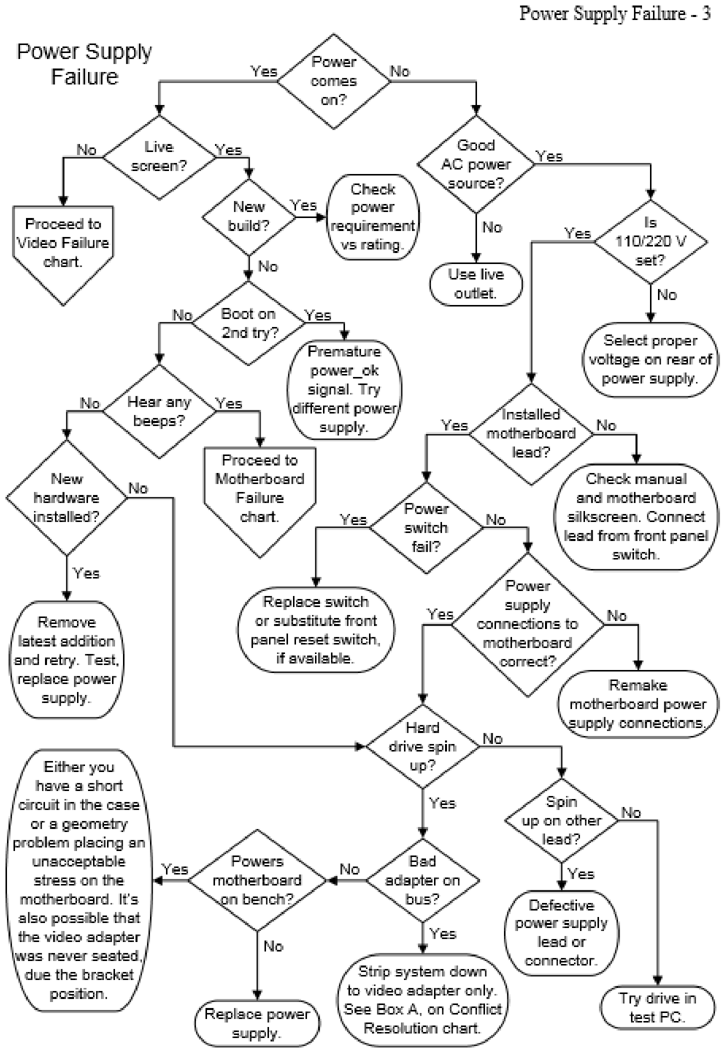

Fig. 1. Power Supply Flowchart [Source: 10]

As we can see, the troubleshooting description is detailed, but is difficult to understand and follow up. Therefore, it is advisable to use intelligent expert systems for repairing hardware. It is necessary to design a knowledge base for the expert system. The source data for the knowledge base can serve as flowcharts or decision trees.

Sample decision trees for creation of knowledge-base are nothing more than restricted types of graphs, just with many more rules to follow.. A tree will always be a graph, but not all graphs will be trees. So, what is it that makes a tree different from the graphs. A tree can only flow in one direction, from the root node to either leaf nodes or child nodes. A tree can also only have one-way connections a child node can only have one parent, and a tree can't have any loops, or cyclical links.

Decision trees are modeling tools that are used in a variety of different settings to organize and break down clusters of data. Similarly, decision tree have been widely used in practical applications area, due to its interpretability and ease of use. The decision tree was used in computer domain to understand the dimension of the problem. Each tree starts with a set of computer problems and ends with solutions.

As a result, representing computer and network problem based on decision tree structure helps the technician or computer user to identify each problem with little effort. Therefore, the system improves the computer troubleshooting service; minimize the burdens of technicians, fill the gaps of limited manpower, delay of time and backlog.

The technicians acquire required information from the computer user. To make this acquired knowledge functional in knowledge representation, the knowledge based system is modeled by using decision tree structures.

Decision tree structures are the bases for the development of prototype knowledge based system. The prototype follows the same procedures as presented in the decision tree when diagnosing computer problems..

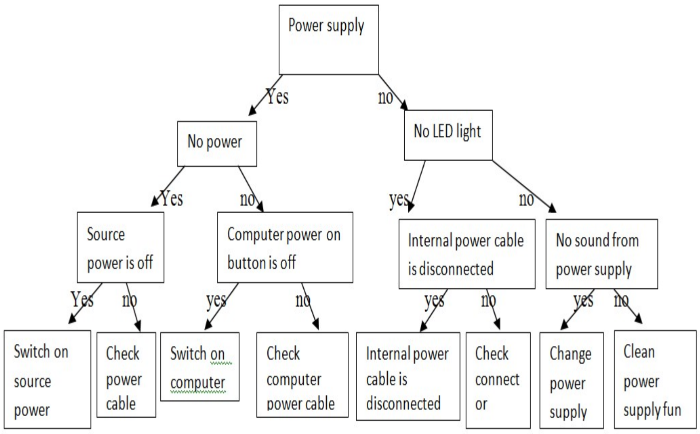

Fig. 2. Decision Tree Part for Power Supply Diagnosis

The common causes of each problem is used to determine the presence of specific cases that has been illustrated (fig.2) using decision tree structures. Based on the decision tree structures, some problems which have similar characteristic in nature were incorporated in the knowledge base to show that some causes can also be causes for other problems. Therefore, similar procedures have been followed for all problems occurring in the computer system. Some of the causes were modeled by using decision tree as follows (fig. 2)

We can write down questions for the knowledge base using flowchart or Decision tree. The number of questions is equal to the number of conditional vertices with two outputs (yes, no) on the power supply flowchart. For this example there will be 15 following "yes-no" questions: (1) Power comes on (2) Live screen (3) Good power source (4) New build (5) Is 110/220 V set (6) Boot on 2nd try (7) Hear any beeps (8) Installed motherboard lead (9) New hardware installed (10) Power switch fail (11) Power supply connections to motherboard correct (12) Hard drive spin up (13) Spin up on other lead (14) Bad adapter on bus (15) Power motherboard on bench.

Similarly, we write down possible faults of power supply, their number will be equal to the number of vertices with one input.

Faults (Response options): 1. proceed to video failure. 2. check power. 3. use live outlet. 4. premature power. 5. select proper voltage. 6. poceed to motherboard. 7. check manual.8. remove latest addition. 9. replace switch. 10. remake motherboard. 11. either you have. 12. defective power supply. 13. replace power supply. 14. strip system. 15. try drive in test PC.

Preparation of the knowledge base for diagnosis of computer components.

We will use the knowledge base of the small expert system [11]. This is simple expert system, using a Bayesian inference system that is intended for consultation with the user in any application area for the loaded knowledge base. The program determines the probability of possible outcomes and uses for this an assessment of the plausibility of certain data, received from the user. An important advantage of this program is the ability to create and use your own knowledge base.

At the first stage of creating a knowledge base, it is necessary to formulate knowledge about the area in question in the form of two sets:

– Q = {qj} - a set of questions (symptoms, evidence)

– V = {vi} - a set of outcome options (solution options),

– two probability matrices : $Py = \{Py_{ij}\}$ and $Pn = \{Pn_{ij}\}$ of size m×n, where

– Py_{ij} is the probability of receiving a positive answer to the j th question if the i-th outcome is correct;

– Pn_{ij} is the probability of receiving a negative answer to the j-th question if the i-th outcome is correct;

Where n and m - the number of questions and outcomes, respectively.

In addition, for each outcome, the a priori probability of a given outcome Papr is assigned, i.e. probability of outcome in the absence of additional information. In the course of expert system operation, the solver, using these sets and matrices and Bayes theorem, determines the a posteriori probability Ppst of each outcome, that is, the probability adjusted according to the user's answer to each question: - with a positive response; - with a negative answer. When the answer is "I do not know" the posterior probability is equal to the prior.

That is, the probability of the implementation of a certain hypothesis in the presence of certain supporting evidence is calculated on the basis of the a priori probability of this hypothesis without supporting evidence and the likelihood of the evidence being carried out under the condition that the hypothesis is correct or incorrect.

The initial information of the knowledge base is the following structure:

Description of the knowledge base, the name of the author, a comment, etc. (can be in several lines; this information is displayed after loading the knowledge base; this section ends after the first empty line)

Question number 0 (any text that ends with line breaks)

Question number 1

Question number 2

Question No. N (the last question is followed by one blank line, and the second section ends)

Outcome 0, P [, i, Py, Pn]

Outcome 1, P [, i, Py, Pn]

Outcome 2, P [, i, Py, Pn]

Outcome N,P [, i, Py, Pn]

The last section lists the outcomes and the corresponding elements of the probability matrices. Each outcome is set on a separate line, the listing ends with the end of the file.

At the beginning of the description of the inference rule, an outcome is specified, the probability of which varies in accordance with this rule. This is text that includes any characters except commas. After the comma, the a priori probability of the given outcome is indicated P. After that, a comma goes through a series of repeating fields of three elements. The first element i is the number of the corresponding question. The next two elements are Pyij and Pnij, respectively, the probability of receiving an answer “Yes” to this question, if the possible outcome is correct and incorrect. These data are indicated for each question associated with a given outcome.

Note: P <= 0.00001 is considered to be equal to zero, and P> = 0.99999 - to one, therefore such values should not be indicated - the outcome with a similar prior probability will not be processed.

For example: (Applied to human health the initial information can be described as follows)

Influenza, 0.01, 1.0.9.0.01, 2.1.0.01, 3.0.0.01

It says here: there is an a priori probability P = 0.01 that any person taken at random has the flu.

The first question (i = 1) corresponds to the record "1.0.9.0.01". Hence, the values $Py_{i1} = 0.9$ and $Pn_{i1} = 0.01$, which means that if the patient has the flu, he will answer “Yes” to this question in nine cases out of ten, and if he does not have the flu, he will answer “Yes” Only in one case out of a hundred (i.e., this symptom is quite rare in other diseases). The answer “Yes” confirms the hypothesis that he has the flu. The answer "No" suggests that a person is not sick with the flu.

If the answer is yes (+5) to the first question, the a posteriori probability for the considered example will be:

$$Papr = \frac{Py_{ij} \cdot P_i}{Py_{ij} \cdot P_i + Pn_{ij} \cdot (1 - P_i)} = 0.47619.$$

If the answer is “No” (-5) to the first question is negative, the posterior probability for the considered example will be:

$$Ppst = \frac{(1 - Py_{ij}) \cdot P_i}{(1 - Py_{ij}) \cdot P_i + (1 - Pn_{ij}) \cdot (1 - P_i)} = 0.00102.$$

If the answer is “I do not know” (0), the posterior probability of the outcome is equal to the a priori.

In the case of an intermediate answer h (from -5 to 0 and from 0 to +5), the posterior probability is calculated taking into account the degree of confidence of the attribute and is calculated by linear interpolation from the values of affirmative answers "Yes", "No", "I do not know".

With a negative answer (-5; 0):

$$Ppst = P_i + (P_i - P_{apr}(not\mathring{A})) \cdot \frac{h}{5}.$$

For example, with the answer h = -3:

Ppst=0.00461

With a negative answer (0; +5):

$$Papr = P_i + (P_{pst}(\mathring{A}) - P_i) \cdot \frac{h}{5}.$$

For example, when answering h = +3:

Papr = 0.28971

For the second question, we have the entry "2,1,0.01." That is, if a person has the flu, then this symptom must be present (Pyi2 = 1) and he will definitely answer “Yes”. The corresponding symptom may occur in the absence of influenza (Pni2 = 0.01), but this is unlikely.

Note: With a large number of questions, it is not necessary to list all of them in the last section of the line, especially if the answer to any question does not affect the probability of the outcome.

Question 3 excludes the flu when the answer is “Yes”, because P (E / H) = 0. This could be a question like the following: “Do you have a given condition for most of your life?” - or something like that.

You need to think, and if you want to get good results, then conduct a study to establish reasonable values for these probabilities.

The values of P (E / H) and P (E / not H), substituted into Bayes theorem, allow us to calculate the posterior probability of the outcome, i.e. probability adjusted according to the user's answer to this question:

P (H / E) = P (E / H) * P (H) / (P (E / H) * P (H) + P (E / H) * P (H)) or

$P_{aposteriori}$ = Py * P / (Py * P + Pn * (1 - P))

The probability of a certain hypothesis H in the presence of certain supporting evidence E is calculated on the basis of the a priori probability of this hypothesis without supporting evidence and the likelihood of evidence being given under the condition that the hypothesis is true or incorrect.

Below there are possible outcomes of the computer component "power supply" diagnosis and the corresponding elements of the probability matrices. Each outcome is set on a separate line, the listing ends with the end of the file.

Outcomes of the knowledge base

1. proceed to video failure, 0.5, 1, 0.9, 0.1, 2, 0.1, 0.9
2. check power, 0.5, 1, 0.9, 0.1, 2, 0.9, 0.1, 4, 0.9, 0.1
3. use live outlet, 0.5, 1, 0.1, 0.9, 3, 0.1, 0.9

4. premature power, 0.5, 1, 0.9, 0.1, 2, 0.9, 0.1, 4, 0.1, 0.9, 6, 0.9, 0.1

5. select proper voltage, 0.5, 1, 0.1, 0.9, 3, 0.9, 0.1, 5, 0.1, 0.9

6. proceed to motherboard, 0.5, 1, 0.9, 0.1, 2, 0.9, 0.1, 4, 0.1, 0.9, 6, 0.1, 0.9, 7, 0.9, 0.1

7. check manual, 0.5, 1, 0.1, 0.9, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.1, 0.9

8. remove latest addition, 0.5, 1, 0.9, 0.1, 2, 0.9, 0.1, 4, 0.1, 0.9, 6, 0.1, 0.9, 7, 0.1, 0.9, 9, 0.9, 0.1

9. replace switch, 0.2, 1, 0.1, 0.9, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.9, 0.1

10. remake motherboard, 0.2, 1, 0.1, 0.9, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.1, 0.9

11. either you have, 0.2, 1, 0.5, 0.5, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.9, 0.1, 12, 0.9, 0.1, 14, 0.1, 0.9, 15, 0.9, 0.1

12. defective power, 0.2, 1, 0.5, 0.5, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.9, 0.1, 12, 0.1, 0.9, 13, 0.9, 0.1

13. replace power, 0.2, 1, 0.5, 0.5, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.9, 0.1, 12, 0.9, 0.1, 14, 0.1, 0.9, 15, 0.1, 0.9

14. strip system, 0.2, 1, 0.5, 0.5, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.9, 0.1, 12, 0.9, 0.1, 14, 0.9, 0.1

15. try drive in test PC, 0.2, 1, 0.1, 0.9, 3, 0.9, 0.1, 5, 0.9, 0.1, 8, 0.9, 0.1, 10, 0.1, 0.9, 11, 0.9, 0.1, 12, 0.1, 0.9, 13, 0.1, 0.9

After processing the data by the expert system, we get the results of the consultation.The purpose of the consultation is to determine the probabilities of possible outcomes.

The result of the consultation (the probabilities of outcomes indicated in parentheses):

(0.39343) check manual; (0.90000) check power; (0.96802) defective power; (0.99961) either you have; (0.99936) proceed to motherboard; (0.99912) premature power; (0.50000) proceed to video failure; (0.90679) remake motherboard; (0.68290) remove latest addition; (0.99022) replace power; (0.21277) replace switch; (0.21268) select proper voltage; (0.98375) strip system; (0.49490) try drive in test PC; (0.02976) use live outlet.

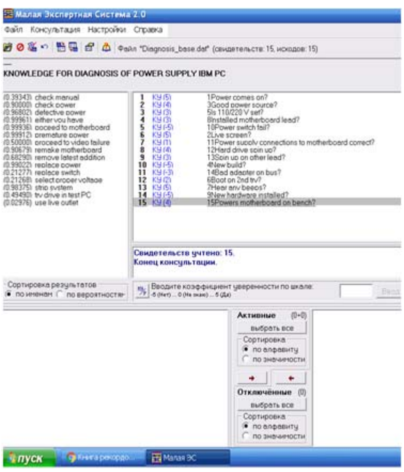

Fig. 3. Expert System Result

Applying the results of the expert system with the probability of a malfunction for each outcomes allows you to optimize the procedure for diagnosing the computer hardware components.

Figure 3 shows the result of the work of the expert system.

Conclusion. The expert system is a computer system that emulates the decision making ability of a human expert. The knowledge-base of the expert system is a computer software expert The proposed system use diagnosis flowchart and decision tree for design the knowledge-base. The expert system use a Bayesian inference system that is intended for consultation with the user in any application area for the loaded knowledge base. During the interviews, questions appear and the user responds by keeping in answers or important data. Then, utilizing the user s response the system searches its knowledge base. It systematically searches through the various paths for a solution without becoming lost in the vast numbers of possibilities. Eventually the program comes up with the advice and communicates it to the user. After processing the data by the expert system, we get the results of the consultation. The purpose of the consultation is to determine the probabilities of possible outcomes.

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Кривуля Г.Ф., Щербак В.К. Проектування бази знань для діагностики комп'ютерних компонентів з використанням блок-схем

У статті пропонується процедура створення бази знань для діагностики комп'ютерних компонентів з використанням блок-схем і методу Байеса. Інтелектуальна експертна система автоматизує процес технічного обслуговування, ремонту і звільняє технічний персонал від ручного виконання рутинних, трудомістких завдань з обслуговування комп'ютерних компонентів. Експертна система виявляє різні апаратні збої, а також дає рекомендації по їх можливої корекції. Продукційні правила пропонованої експертної системи виконуються у вигляді операцій «якщо-то». Експертна система веде діалог з користувачем, отримує дані про проблему і ставить запитання в процесі консультацій з користувачем. Під час консультації на екрані комп'ютера з'являються питання; користувач відповідає, зберігаючи відповіді або важливі дані. Експертна діагностична система готує відповідь користувачеві з використанням байєсівського методу і бази знань. Застосування виданих експертної системи ймовірностей для кожної несправності дозволяє оптимізувати процедуру діагностики компонентів комп'ютерного обладнання

Ключові слова: *діагностика, система знань, експертна система, блок-схема, байєсівськїй метод*

Кривуля Г.Ф., Щербак В.К. Проектирование базы знаний для диагностики компьютерных компонентов с использованием блок-схем

В статье рассмотрена процедура создания базы знаний для диагностики компьютерных компонентов с использованием блок-схем и метода Байеса. Интеллектуальная экспертная система автоматизирует процесс технического обслуживания, ремонта и освобождает технический персонал от ручного выполнения рутинных, трудоемких задач по обслуживанию компьютерных компонентов. Экспертная система обнаруживает различные аппаратные сбои, а также дает рекомендации по их возможной коррекции. Продукционные правила экспертной системы выполняются в виде операций «если-то». Экспертная система ведет диалог с пользователем, получает данные о проблеме и задает вопросы в процессе консультаций с пользователем. Во время консультации на экране компьютера появляются вопросы; пользователь отвечает, сохраняя ответы или важные данные. Экспертная диагностическая система готовит ответ пользователю с использованием байесовского метода и базы знаний. Применение выданных экспертной системы вероятностей для каждой неисправности позволяет оптимизировать процедуру диагностики компонентов компьютерного оборудования

Ключевые слова*: диагностика, система знаний, экспертная система, блок-схема, байесовский метод*

Кривуля Геннадій Федорович – д.т.н., професор кафедри автоматизації проектування обчислювальної техніки Харківського національного університету радіоелектроніки; професор кафедри комп'ютерних наук та інженерії Східноукраїнського національного університету ім. В.Даля, email: krivoulya@i.ua

Щербак Владислав Костянтинович – аспірант кафедри автоматизації проектування обчислювальної техніки Харківського національного університету радіоелектроніки

Рецензент: д.т.н., проф. ***Рязанцев О.І.***

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