CONCEPT OF SYSTEM SUPPORTING SELF-STUDY PROCESS OF DIAGNOSTICIANS

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Summary

One of the element of the work of employees of maintenance services is a process of improving their knowledge. So it is important to prepare such a system which could help that process. The aim of this paper is a concept of the system that allow support learning process of maintenance service staff. In this paper the author presents two main parts of this system. The first one that is connected with representation of diagnostic knowledge. The second part of the system will help to decide which part of the knowledge is suitable for the employee. The author assumed that the system will be dynamically fit to the knowledge of the employee. The knowledge will be divided into small parts, so each of them could be used in many different themes. Basis of them the system could decide which part of them is adequate to the actual knowledge of the employee.

Key words: applications, artificial intelligence, education and training in CM, decision support for CM.

KONCEPCJA SYSTEMU WSPOMAGAJĄCEGO PROCES SAMOKSZTAŁCENIA PRACOWNIKÓW UTRZYMANIA RUCHU

Streszczenie

Jednym z elementów pracy służb utrzymania ruchu jest proces samodoskonalenia swojej wiedzy i umiejętności. Istotnym więc wydaje się opracowanie systemu, który mógłby wspomóc ten proces. Tematem tego referatu jest przedstawienie koncepcji takiego systemu, który wspomógłby proces samokształcenia służb utrzymania ruchu. W pracy autor przedstawia dwa główne elementy takiego systemu. Pierwszy element związany jest reprezentacją wiedzy diagnostycznej. Drugi z elementów systemu ma pomóc wybrać tę część wiedzy, która będzie najbardziej właściwa dla danego pracownika. Zakłada się, że system będzie się dostosowywał do wiedzy pracownika. Wiedza będzie podzielona na części, dzięki czemu będzie można je wykorzystać w wielu różnych tematach. Na tej podstawie system będzie mógł decydować jaką wiedzę należy przekazać pracownikowi w stosunku do posiadanej przez niego wiedzy.

Słowa kluczowe: aplikacje, sztuczna inteligencja, nauczanie i szkolenie w utrzymaniu ruchu, wspomaganie decyzji w utrzymaniu ruchu.

INTRODUCTION

Nowadays the maintenance is a very important part of industrial activities. The definition of maintenance that can be find in [1], describe it as series of all actions made during the life cycle of a

maintenance is carried out usually in specified time intervals or based on predefined criteria. So, the preventive maintenance can be divided into predetermined or on condition based. The predetermined maintenance is based on predefined schedules that are previously planned. In the condition based maintenance, the decision about reparation of the equipment is taken basis on the results of signal analysis and/or evaluation of the significant parameters of the degradation of the equipment. On the other hand we have the corrective maintenance. In this kind of maintenance the state is carried out after fault recognition. After machine, to retain it in, or restore it to, a state in which it can perform the required function.

On the Fig. 1. are presented types of maintenance defined by the European standard for maintenance terminology [2].

Preventive

that the equipment should be put into the state in which it can perform a required function. This kind of maintenance can be immediate or deferred.

The condition based maintenance (CBM) [1, 14] has been implemented in the industry with success. Because of complexity of industry processes and machines in many cases in the industry the condition based maintenance is use more often. All this is connected with [3]:

- manufacturing diversity,
- process diversity and complexity,
- accessibility to the site or process,

- development of the information and communication technologies which are implemented to improve maintenance practice,
- treated maintenance as a part of the whole production process.

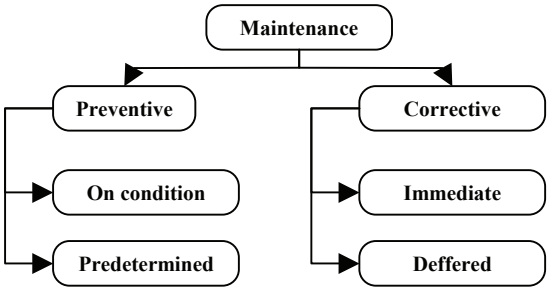

Fig. 1. Maintenance types describes in EN 13306:2001 [1]

In last few years new techniques and methods connected with information and communication technologies (ICTs) are developed or improved. It is worth to pay attention to several elements. The first one is connected with miniaturization technologies of equippments used for data acquisition. New smaller sensor systems and optical micro-sensors are developed. Miniaturization also applies to mobile devices. The dynamic development of such devices allows their use in maintenance. Devices such as PDAs or tablets have become convenient tools for maintenance systems. The second one is standardization for data and information communication. There are developed or improved standards for wireless communication like WiFi, Bluetooth or ZigBee. In implementations of maintenance systems usually is required an integration of a various hardware and software elements. With this in mind has been developed an open system architecture OSA. The open system architecture was prepared for condition based maintenance system. The standard is developed and supported by the operations and maintenance information open systems alliance (MIMOSA) [3, 4]. All these new developments has given rise to a new kind of maintenance which is called e-maintenance [1, 3]. The e-maintenance is "a new concept that can be defined as a maintenance support which includes the resources, services and management necessary to enable proactive decision process execution. This support includes e-technologies (i.e. ICT, Web-based, tether-free, wireless, infotronics technologies) but also e-maintenance activities (operations or processes) such as e-monitoring, e-diagnosis, e-prognosis …" [1]. The insertion of e-maintenance solutions can increase the efficiency of the work and reduce manufacturing costs. Maintenance tasks tend to be difficult because they require expert technicians. Because of that, the technicians permanently need to improve their knowledge about maintenance. International organizations have elaborate guidelines of competency requirements for maintenance functions. In Europe this kind of guidelines was specified by European Federation of National Maintenance Societies (EFNMS). The EFNMS has specified the competence requirements. Requirements have been developed for both technician specialists and maintenance management. Therefore, it seems that there is a need to develop a system that would help both deepen existing knowledge as well as enable the employee to acquire new knowledge in this field.

1. E-LEARNING

Nowadays, when many people use Internet, it is naturally to take a challenge for application of it to a e-learning medium. New technologies using in the Internet, let us to teach somebody more effective and flexible. In the Internet, knowledge could be transfer using different forms, like: text, pictures, sound, films, virtual models and virtual reality, live presentations etc. Many special systems using network environment like Internet and Intranet are prepared as e-learning solutions. Most of them enable courses as static hypertext presentations. But in the last few years, educational applications are developed that offer more that only static presentations. Some of them contain modules connected with artificial intelligence. Methods and techniques well known from artificial intelligence domain are used in e-learning. All this systems are called Adaptive and Intelligent Web-Based Educational Systems (AIWBES) [9, 10].

E-learning could be realised in different forms. Many of them have evolved and changed. So, it is possible to divide this learning methods into four main forms [11]:

- help database,
- online support,
- asynchronous method,
- synchronous method.

One of the first and relatively simple form used in e-learning are help databases. These methods are based on principle that users or students could prepare queries to database. Results of the queries are used for learning. Databases are used for example by software companies to help users in exceptional or emergencies situations. Information could be retrieve using keywords, context searching or table of contents.

Another form of e-learning is online support. This form of learning is quite similar to databases. In this method we could also search for information using queries. Moreover, users can exchange opinions on special discussion forum or read bulletins in this method.

The best known form of e-learning is asynchronous method. In this method, users are learning in their own individual speed. This

education method could be led with or without a teacher. The main role of the teacher is to lead users through the course and answer questions. Users communicate with teacher by e-mail, discussion forum or bulletin. If course is lead without teacher, users are referenced to prepared materials.

In synchronous method the knowledge is transferred by a teacher in real time. At specified time all users and teacher connect all together. At this time, all connected users could view a virtual blackboard. On this blackboard, teacher explains discussed problems. All users may ask some questions and all users can read or hear answers. This kind of courses may be performed ones or be repeated periodically.

Analysing computer systems aiding e-learning, it is possible to notice that some of the elements are common. The basic elements occurred in this kind of systems are [11]:

- content,
- communication,
- virtual reality,
- work coordination,
- tools,
- grade systems,
- reports.

Content is the main element of every e-learning system. It could be relayed using different currier like video cassetes, compact discs or Internet. Very usefull for learning may be virtual reality. Using virtual, reality teacher could present virtual experiments, functioning of some machines, etc. Tools are usefull aid in contetnts preparation. Nowadays tools are very complex and could simplify the teachers work.

2. COURSE ORGANISATION METHODS

The process of working courses out for Internet e-learning solutions is a very complex and time-consuming. It is computed that preparing materials for e-learning take up many hours per course. Courses might be organised using different structures. The well known structures are as follows [12]:

- classic tutorials,
- activity-centred lessons,
- user customized tutorials,
- knowledge paced tutorials,

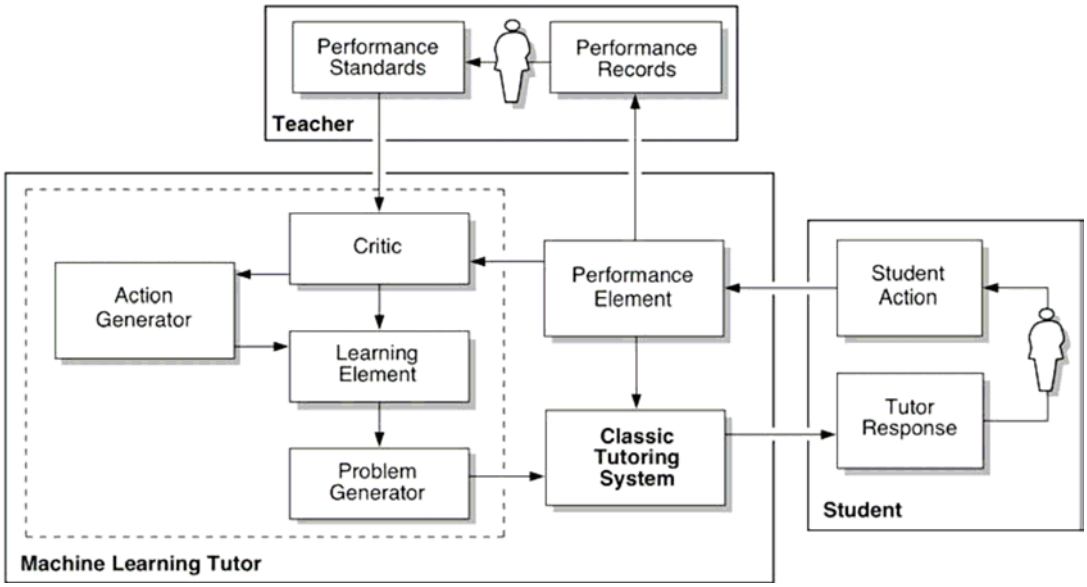

Fig. 2. Components of machine learning techniques integrated into an intelligent tutor [5]

- exploratory tutorials,
- generated lessons.

In the classic tutorial, user start with an introduction. After that, it is proceeded a sequence of pages that learns progressively more advanced materials. At the end of this tutorial, user encounter some kind of summary or review and test or other activity measure method. The classic tutorials has many variants.

Next type of structure is activity centred lessons. This method is built on a single activity. It also possess an introduction containing a preparation page. After that the user is prepared for activity. After the activity the main elements of the activity is recaps on a summarise page. Special attention should be paid on preparation page. The following elements should be presented for example on this page [12]:

- goals of the activity,
- rules of the behaviour of the activity,
- links for needed information.

The user customised tutorial structure is very interesting. Some paths in a course branch in this method. This branching depends on knowledge or

desire of the user individual preferences. Like in former structures, in this method course is started with an introduction page and finished with an summary page. But user is able to choose different

learning techniques is to enable in this kind of systems experiences from learning process. In [5] we can read that machine learning techniques are used in intelligent tutors to acquire new knowledge

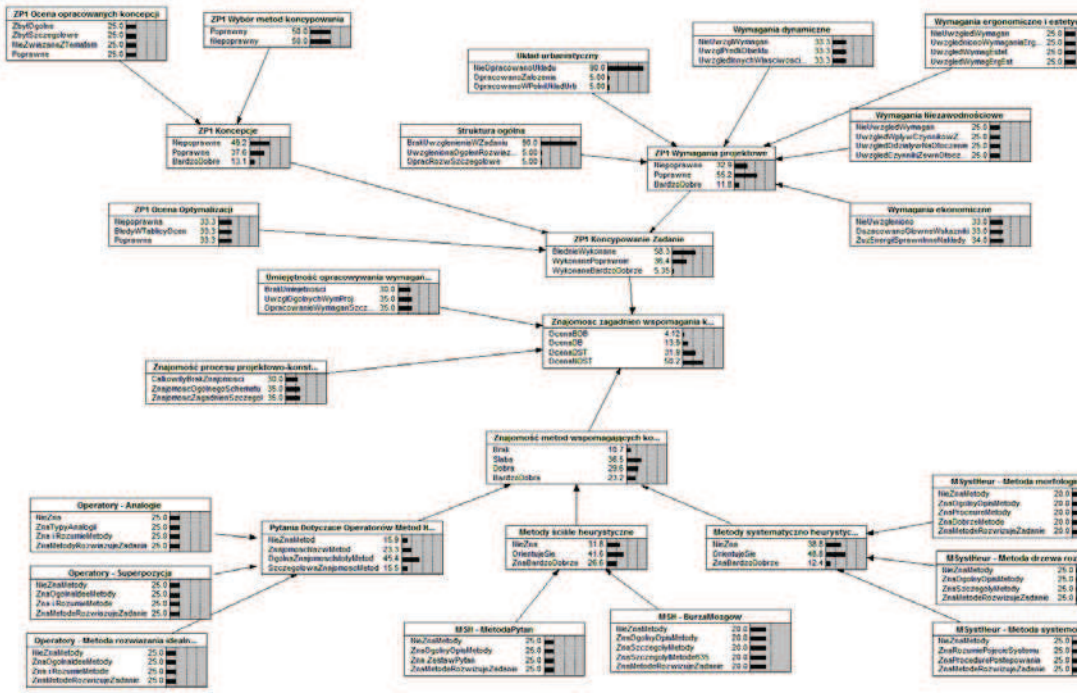

Fig. 3. Example of Bayesian belief network for improving learning process in machine designing

paths from start to the end. On the branch page, user should find list of paths to choose from. User also may be tested and automatically directed into chosen path based on the test results.

In the knowledge based tutorial user skip lessons that he already well know. To skip lesson user should pass a test. The next test is more difficult that the previous one. If the user fail to pass a test, he is directed into lesson which deals with materials required to the last test.

In exploratory tutorial, user has some goals and access into electronic collection of knowledge. He should explore this collection in order to achieve goals. After accomplishing each of the goals, user should pass a test.

The finally one of the architectures of courses organised structure is architecture of generated lesson. This method bases on answers to a test or questionnaire. Bases of these answers, course is generated automatically individually to the user.

3. MACHINE LEARNING TECHNIQUES

Modern systems to conduct the learning process in an automatic manner, utilize principles of machine learning techniques. Techniques of this type are used to observe and evaluate the tutor's actions. The reason for the application of machine

about students, identify their skills and learn new teaching approaches. Using these technique can improve the teaching process. This is done by increasing tutor flexibility, reducing tutor costs and adapting to new student population. On Fig. 2 we can see the learning environment with machine learning elements. The environment consists of three types of models. Model of the student, model of the teacher and model of the machine learning tutor [5]. From a group of machine learning methods in the teaching process, the following methods are applied:

- Bayesian belief network,
- reinforcement learning,
- hidden Markov models,
- decision theory,
- fuzzy logic.

A short information about these techniques were described below.

3.1. Bayesian belief networks

The concept of Bayesian belief network is based on the Bayes theorem. In this theorem we can calculate the probability between events and the conditional probabilities between these events. The meaning of calculated values depends on their interpretation. We have two types of interpretation of these calculated values: Bayesian interpretation

and frequentist interpretation [7]. In the Bayesian interpretation the probability is a measure of degree of belief. The frequentist interpretation defines the probability with respect to a large number of trials. The Bayesian belief networks used the first of these interpretation.

Bayesian belief networks are widely used in various fields of knowledge. They are used to speech recognition, natural language understanding, user modelling, medical diagnosis, forensic analysis, fault diagnosis, visual tracking, data compression, and genetic analysis [5, 8, 9]. They are applicable in many diagnostic of machine systems [15, 17], several medical systems or nuclear power plants. This kind of knowledge representation is used also in teaching systems [16, 18, 19]. Bayesian belief networks are also used in automatic teaching process. In these solutions, they are used to [5]:

- support classification and prediction,
- student knowledge modeling,
- predict student behavior,
- make tutoring decision,
- determine steps on which students will need help and their probable method for solving problems.

On Fig. 3. Is presented an example of a Bayesian belief network prepared for an analyze of assessing the progress of students.

3.2. Reinforcement learning

The essence of this technique bases on principles that are used by humans or animals to gain experience through random trial and error. This method is an example of unsupervised learning. Referring to the comparison with nature, people or animals learn in this way without the teacher, who would point them the right way, by interact with an environment. In the computing environment like in reality, it is necessary to determine the participant's interaction with the environment. In the computing environment it is realised by agent-based solutions. Agents can be both humans and computers. The operation of such an agent is based on doing tasks to derive the maximum profits. Therefore, we use here the rewards and punishments method. Behavior leading to a particular purpose are rewarded and those that do not comply with the stated objective are punished. Because these methods are associated with high computational expenses, we should remember to retain a balance between exploration of new territories and exploitation (of current knowledge) [5].

An example of the system working on the principle of reinforcement learning is a system for learning to ride a bike [5]. The goal of this system is simply learning to ride a bike. System operation is based on gaining experience with riding a bike based on the position of the bike in relation to the road. If the bike leans to the left, we have two choices, lean even more to the left or lean to the right. If the system will strongly leans to left the bike fall over. If the system tilt the bike to the right, the bike will go on. In the next case, the bike leans to the right. The system remember that if the bike leans to the right it was a proper solution. But in this case this is of course bad solution. Just tilt the bike to the left to continue its journey with success. So, the next experience gathered by the system will be the direction of tilt. And so, through trials and errors the system learns how to ride a bike.

3.3. Hidden Markov models

A hidden Markov model (HMM) is a statistical Markov model in which the system being modeled as assumed to be a Markov process with unobserved (hidden) states [8]. The hidden Markov model is the simplest case of dynamic Bayesian networks. Using this model we can observed some changes of states without the observation of the states themselves. Instead of that we observe some probabilistic function of those states. A simple example, was proposed by by Jason Eisner in 2002 [9], "Ice Cream Climatology":

"The situation: You are a climatologist in the year 2799, studying the history of global warming. You can't find any records of Baltimore weather, but you do find my (Jason Eisner's) diary, in which I assiduously recorded how much ice cream I ate each day. What can you figure out from this about the weather that summer?"

Using hidden Markov model we can describe this scenario. We don't get to observe the weather on each day which are hidden states. But we can observe how many ice creams were eaten that day, which are a probabilistic function of the process.

This kind of model is used in many applications such as: speech recognition, handwriting, gesture recognition, part-of-speech tagging, musical score following, partial discharges and bioinformatics [8]. Hidden Markov models are also used in systems supporting the learning process. There are used for studies validation, to model student behavior, to model student's mastery of the knowledge [5]. An example of simple learning system using this method is presented in [13].

3.4. Decision theory

Decision theoretic networks are another machine learning technique that we can use in intelligent learning systems. This technique is based on decision theory, that is closely related with probability theory. The idea of using the decision theory in teaching systems, is to find a proper plan or action with minimal costs. These kind of technique we can use to determine the next step of learning process or to choose the next test perform when current tests were not sufficient. There are many application of using decision theory to

intelligent learning systems like DT Tutor, More tutor or CAPIT System [5].

3.4. Fuzzy logic

The fuzzy logic technique was developed by Lofti Zadeh who proposed the fuzzy set theory. It was developed to expand the classical logic theory. It can be used to describe the ambiguity and contradictions. This method has been widely used in many engineering solutions such as control systems, expert systems or knowledge engineering. In intelligent learning systems the fuzzy logic is used to represent the uncertainty of knowledge. In these kind of system the fuzzy logic is used to convert the knowledge with subjective concepts into numeric values. We can use it also to formulate ambiguous descriptive terms in the responses of students or verbal evaluations of students' knowledge.

4. SUPPORT LEARNING PROCESS SYSTEM

One of the element of the work of employees of maintenance services is a process of improving their knowledge. So it is important to prepare such a system which could help that process. In this part of paper I wish to present a concept of a system that allow support learning process of maintenance service staff. This kind of systems should have two main parts. The first one that is connected with representation of diagnostic knowledge. The second part of the system will help to decide which part of the knowledge is suitable for the employee. Using the current knowledge about that systems it is assumed that it should dynamically fit to the knowledge of the employee. To do this, knowledge will be divided into small parts, so each of them could be used in many different themes.

4.1. Knowledge representation

The main element of any system that is aided by artificial intelligence methods is the knowledge base. In this system we need to use knowledge bases to save the knowledge about:

- supported object,
- object maintenance content,
- user personalized skills.

The knowledge about the supported object can be taken from maintenance system that are used on the object. If the object has no maintenance system built in, for the information about the object should be saved in database with MIMOSA schema. Very interesting part of knowledge is the knowledge about object maintenance. In many cases the

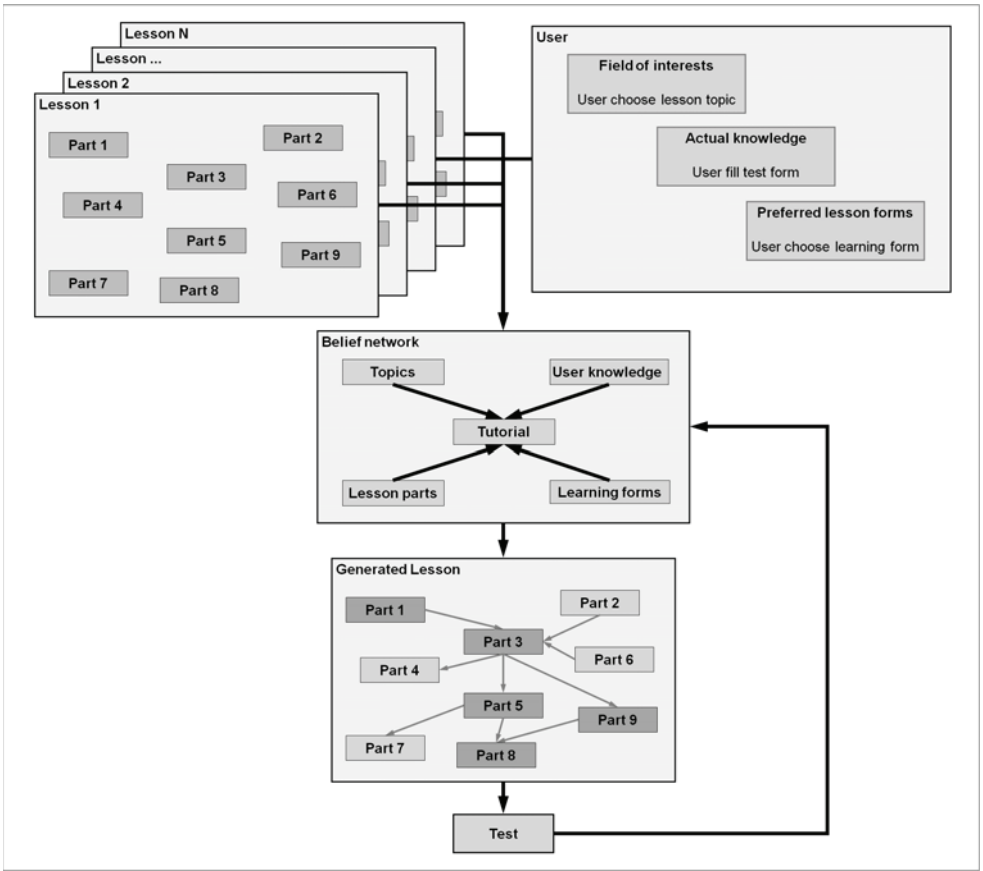

Fig. 4. Schema of the course organization environment

knowledge representation about maintenance of an object depends on the system that is used in the given factory. But in general I propose to use a mixed representation. For the maintenance data it is proposed a database with MIMOSA schema. That is a very useful and exchangeable standard. But we need to have also the knowledge about changing of the machine state. So it is proposed to use one of the machine learning technique for this. It is considered that a Bayesian belief networks or hidden Markov models will be helpful for this.

The last part is the knowledge possessed by an employee. His/her knowledge will be represented as a Bayesian belief network.

4.1. Concept of course organization environment

One of the main question in preparing the systems is how to represent the knowledge and how to organize it. If the organization of the course is incorrect then it could disturb the learning process. If it is well organized, employee should assimilate knowledge quickly and more effectively. At this point, a concept of a course organisation method is presented. I set up that the main user of that system is an employee.

A concept of an environment appropriate for e-learning is proposed. In this environment, user is the main element of the learning system. Each of the user has different knowledge and experience. So the main task of the system is organize the course for the user personally. The concept of this method is based on architecture of generated lessons. In this method, lessons should be generated automatically, individually to the user. Topics presented in lessons may be described with the application of different forms. A part of the lesson is prepared for every form. Sets of lesson parts are defined in the learning system. Each of the part is used for description of one point of view. The main task of the system is to generate lesson from the parts. The question is how the system should choose the course and which of them may be preferred by the user. Selection of the lesson elements can be generated based on:

- information about field of interests of the user,
- his actual knowledge,
- information about forms of lessons preferred by users.

Field of interest should define area of knowledge which the user would like to discover or to improve. His actual knowledge is used to limiting knowledge area that he should learn. The most important is how he should learn new topics. What kind of learning forms is the best for him. Many users prefer learning based on samples. Others prefer learning based on theoretical aspects of topics. Some peoples would like to read text. Others prefer listen to it. So based on them, it is possible to define different reasons that could influence on the lessons content. Generating lessons mechanism is based on belief network.

It is proposed, that lessons are organised as belief network in this solution. Nodes in this network correspond to lesson parts, field of interest of the user, actual knowledge of the user and learning forms that are available in the learning system. The problem is how to calculate values of nodes in the belief network. At the beginning, values of all nodes are imposed. These values are changed during system running. There are many reasons that could cause modification of nodes values like:

- user topic selection,
- identification of actual user knowledge,
- user preferences about learning forms,
- lesson parts available in the system.

In the first step user should define learning topic. Based on them, system is able to limit content of the lesson. Content of the lesson is limited through modification of node values. In the next step, user is allowed to pass test. Based on results of the test it is possible to determine the actual user knowledge and also modify value of nodes. At the end, user should fill a questioner. In this questioner user identify its preferences about learning forms. Finally, user is able to start the learning process. At the end of the learning process, its efficiency is verified using test. If user passes the test the learning process could be finished. If not, values in nodes in the belief network are modified and a new lesson is generated.

5. SUMMARY

In this paper, the idea of e-learning environment, that could prepare personalized lessons for maintenance employees, is described. This idea is based on architecture of generated lessons. There is a set of lesson parts and system which should propose lesson content the most efficient for the user. Problem of selection of the lessons content is solved with the application of Bayesian network. In this article is presented only an idea of this system. The system is in project mode and will realized in small environment.

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