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AN ARTIFICIAL INTELLIGENCE AS A TOOL FOR MONITORING THE RELIABILITY, THE SAFENESS AND ECONOMIC EXPEDIENCE OF THE TRANSPORT DEVICES

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There is a basic concept of the inference engine designed using decision according to criteria described in this article, as well as the basic concept of an artificial intelligence and the main parts of an expert system (designed and created by the author) especially – Communication module, Basis of knowledge, Inference engine, Basis of facts, Module for getting information. There are results of described expert system in praxis in the airports and hardware and software requirements for expert system realization.

Keywords: the artificial intelligence, the expert system, inference engine, communication module, basis of knowledge, basis of facts, module for getting information, aircraft, failure rate, flying hours cost

1. Introduction

Using of informatics technologies is indispensable trend in the all areas of our life. In this time we cannot imagine any activity without using up-to-date technologies. One of the most important trends in informatics is artificial intelligence and its expert systems development.

An Artificial Intelligence is the area of computer science focusing on creating machines that can engage on behaviours that humans consider intelligent. The ability to create intelligent machines has intrigued humans since ancient times and today with the advent of the computer and 50 years of research into AI programming techniques, the dream of smart machines is becoming a reality. Researchers are creating systems which can mimic human thought, understand speech, beat the best human chess player, and countless other feats never before possible. Find out how the military is applying AI logic to its hi-tech systems, and how in the near future artificial intelligence may impact our lives. A big success of artificial intelligence was an expert system's creation.

Expert systems are sets of computer programs and appropriately chosen and structured data, which nature and quality of its functions can in some cases equally substitute qualified and skilled work of experts in the field of their specialization.

Expert systems have got legitimate place also in operating the aircrafts, as it is described in the further parts of the article.

The aircraft operator is asking these questions when purchasing a device – how is the device able to fulfil its function, is it better to operate older device or buy new, what is the maintenance quality comparing to other operators? Expert system described in this article helps to find the right answers to these questions.

2. Why to Create the Expert System for Monitoring the Reliability, the Safeness and Economic Expedience of the Transport Devices?

People in its whole history meet a problem with reliability of systems they are working with. The problem is all the time the same – to achieve working of this systems as long as possible without accidents or at least with number of accidents as small as possible. To this basic request are associated the other: to achieve from these systems performing their functions as good as possible, be as cheap as possible, using energy as small as possible, having weight as little as possible, accusing space as small as possible, etc.

It is the nature of people to do their job the best they can. It's necessary to make a lot of decisions every day. Many times a small mistake in a decision might have a strong effect on further success of performed work. And that's why it is important to have a chance to consult decision-making with someone who knows the subject of decision the best – i.e. with an expert. Sometimes you can't find such an expert. One of the outcomes of IT application development is expert systems that can substitute this expert.

Expert systems are one of the most successful applicable solutions in the research of artificial intelligence. Expert systems are sets of computer programs and appropriately chosen and structured data which nature and quality of its functions can in some cases equally substitute qualified and skilled work of experts in the field of their specialization..

Expert systems have got legitimate place also in operating of devices, as is described in the next part of the article.

During using arbitrary systems are there question, if way of operating is appropriate for given devices, what are reliability parameters of their devices in comparison with another operators, what is the maintenance quality comparing to other operators, what is the maintenance influence on reliability these devices considering to economic of devices running.

Main target of manufacturer and operator is to raise safeness and reliability of their devices while reducing operational costs. It is necessary for this purpose „to measure" someway reliability and then evaluate if arrives and when. Operator of transport devices asks himself next questions:

- Can I guard device running better and cheaper?
- Are the other operators better?
- Is it advisable to operate old device or to buy a new one?
- What device on the market is the best for me?
- Will a new device be able sub serve the required tasks all right?
- Will organization or technologic change contribute to raising of affectivity and reliability our work?

Answers to these questions are offered by the expert system described in the next part that is designed by the author.

3. Design of Expert System for Evaluation of Transport Devices

A main target of the science of the safeness and reliability problem is to find out methods and procedures that enable practice analysis safeness and reliability already existing systems. These methods are included in the expert systems modules that are able to perform this analysis using given values and „advise "to the operator to find out answers to listed above questions.

Described expert system can give well-knit view over ability several types of devices from the point of view of many different criteria – it can be safeness, operating economic, fitness for using for specific operator and lot of others. Expert system executes calculating inscribed characteristics and then is able to evaluate types of devices according to computing results.

It enables to choice the importance of single criteria according to what criteria is now most important and it allows to insert another criteria by them would be possible to evaluate devices. It enables perform another evaluations, for example comparing of operating effectiveness of the same device types from various operators. The comparison width will depend on entry values quantity into the expert system.

This expert system has a very important property – it can work very simply with available information and user need not a lot of money for getting this information.

There is a basic configuration of expert system showed on Figure 1.

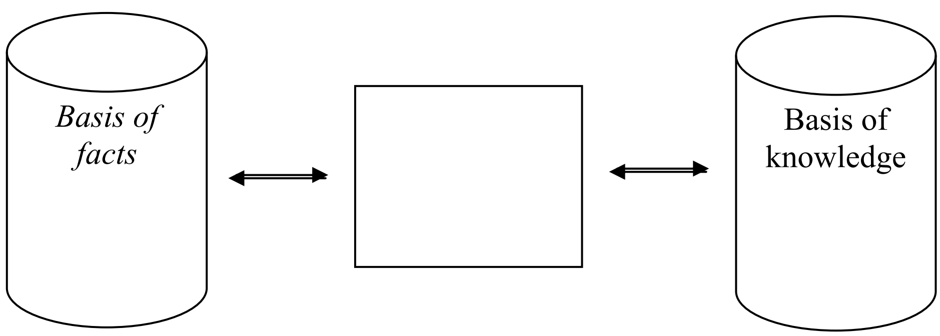


Figure 1. Basic configuration of an expert system

3.1. An architecture of expert system for transport devices evaluation

I have designed the expert system according to scheme showed on Figure 2. Its configuration is created of the following components:

- Communication module
- Basis of knowledge
- Inference engine
- Basis of facts
- Module for getting information

In the next part the most important components of expert system in details are described, that is, the Basis of facts and the Basis of knowledge that present input values of expert system and the Inference engine that make the required output values by data computing the input values. Output values of expert system will be device evaluations from the point of view of the required criteria.

Communication module – created in any object–oriented language program, is used by operator to communicate with an expert system. It allows to start the expert system, to put input values, to perform values processing, choosing criteria and to end running of expert system.

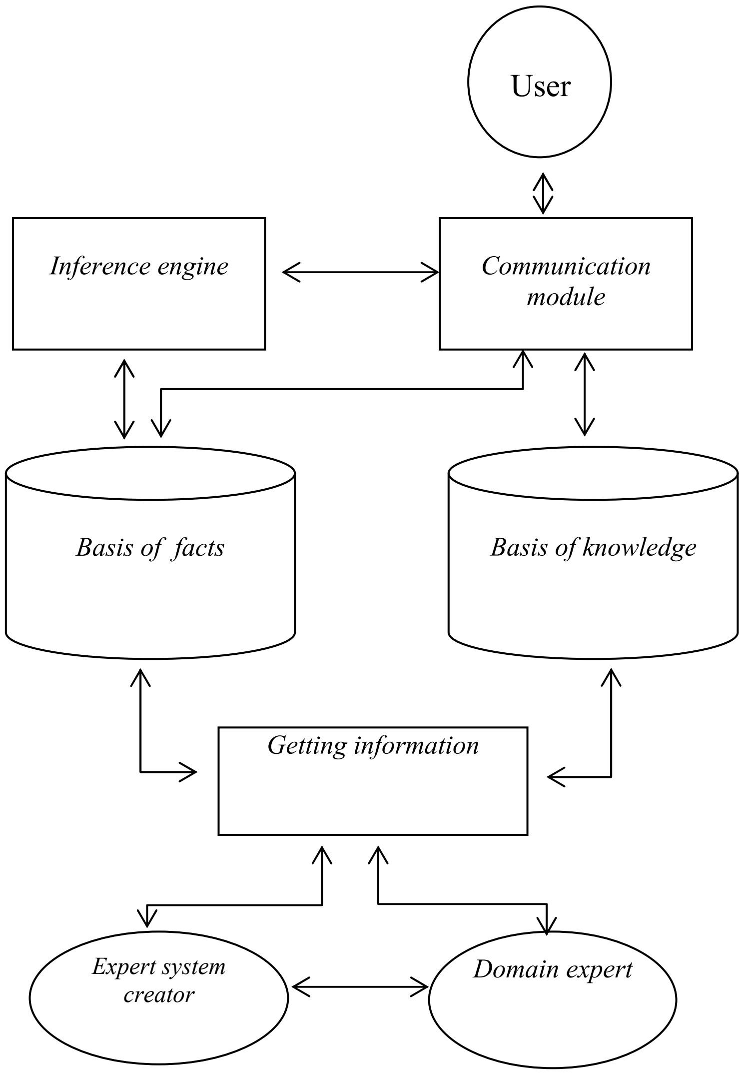


Figure 2. Expert system scheme

Basis of knowledge – contains modules for computing individual criteria, functions and formulas for criteria calculation and data from „expert” for maintenance.

Design of Inference engine – creates one of the most important and most complicated part of the expert system design. Inference engine is selected in the way to exactly answer the purpose that expert system has to solve. It is not too complicated and blind for possibility to operatively modify expert system and to update with new modules. It is composed with Basis of knowledge rules concatenation and creating of various rule sequences for achieving the final result. It is created from program modules in VBA language executing overall evaluations concerning all criteria; it allows making choice of some criteria and putting weights to the criteria, which are the most important in the moment.

Basis of facts is created by inputs about operation and maintenance devices at transport operator. They are inputs of expert system**.**

4. Filling the Expert System for Airlifting

In the next part the expert system that I have established by filling of specific inputs from aircraft operating on university of Žilina and SNA in Bratislava is described.

Basis of knowledge is created by:

Mc. Crackens model of aircraft operating reliability for calculation of smartness and the probability of failure-free operating.

Function for failure rate calculation for failure evaluation.

Standard method for straight operating expense evaluation – SBAC for calculating of flying hour expense

Basis of facts included as follows:

Technical data about aircraft periodical maintenance on University of Žilina

Total air-raid in spotted periods in operator of university of Žilina

Average daily air-raid

Average daily count of starts

Inputs from the maintenance „expert“

Inputs about failures and repairs of individual aircraft in ŽU and SNA

Data for tax calculating of a flying hour

4.1. Description of the Inference Engine

If we are available to a big amount of values that are of different character it is very difficult to compare them without any transformation or data handling into the form, that would suffer realizing this transformation automatically. Problems of this type are solved by application of the more-criteria decision method, for example, by the concordant analysis. But in this case are expected accounts with matrix of values what is very complicated problem and especially we achieve the same regular result with more simple solution.

In described expert system is used school marks principle. Each area is evaluated particularly so that the type of the airplane that fly in the given area (according the criteria of the given area) obtains the best result, obtains mark 1. The other types get mark by degrees lower. It enables to use this criteria processing method because amount of aircraft the expert system is processing with is not very large, i.e. the count of the device types is relatively little.

Final valuation is the mark that is composed by arithmetic average of the all marks.

It may occur at the situation that all results will be the same for all the aircraft types or almost the same. In this case the user can enter to weight for any criteria. To put the weight for any criteria is possible whenever, it depends on the criteria important.

If it isn't important any criterion in decisive moment, expert system will allocate to this criteria value 0 as the mark for every type of an aircraft.

For using this expert system in the future is suitable opening this expert system for the choice of other criteria. It is designed in such way that will be possible put in it certain amount of the criteria while the user will have to execute calculations for the particular aircraft types without expert system, if the calculation algorithms are not known in this time.

5. Realization of the Described Expert System in the Airport Žilina and SNA Bratislava

To filling my expert system I have used actual data from airports Žilina and SNA Bratislava. At first an expert system has made the following account:

5.1. Failure evaluation of the same types of aircrafts at operators Žilina and SNA Bratislava

Input data are – number and type of a failures and the air raid number of aircrafts Z 42, Z 142, L 200 a Z 43 in the Table 1.

Table 1. The aircrafts failure comparison at Žilina and SNA Bratislava

Year 2006	**Failure rate – Žilina**	**Failure rate – SNA**	**Lower failure rate has:**
Aircraft Type	Light	Light	
Z – 43	0,022528442	0,002684564	**SNA**
Z – 42	0,030176533	0,055555556	**Žilina**
Z – 142	0,015168857	0,005008347	**SNA**
L – 200	0,037243948	0,016260163	**SNA**

5.2. Field reliability evaluation of several types of aircraft at operator in Žilina

To get the final evaluation values of the several criteria for all of aircraft types have been calculated and the best aircraft type for each evaluated. Criteria are the following:

failure rate evaluation,

flying hours costs evaluation,

evaluation of the no-failure operation expectation,

the ground alert evaluation.

5.2.1. Final evaluation according all of criteria – the weight of criteria is the same (Tables 2-6)

Table 2. The aircrafts sequence in the comparison of the several criteria

Failure rate	Flying hours costs	No-failure operation	Severability
Z – 142	**Z – 42**	**Z – 142**	**Z – 142**
Z – 43	Z – 142	Z – 42	Z – 42
L – 200	Z – 43	L – 200	Z – 43
Z – 42	L – 200	Z – 43	L – 200

Table 3. Marks assignment according to particular criteria without weight of criteria

Aircraft type	Failure rate	Flying hours costs	No-failure operation	Severability	Final mark
L – 200	3	4	3	4	3,5
Z – 142	1	2	1	1	1,25
Z – 42	4	1	2	2	2,25
Z – 43	2	3	4	3	3

Table 4. Marks assignment according to particular criteria using weight of criteria (weight of criteria =1)

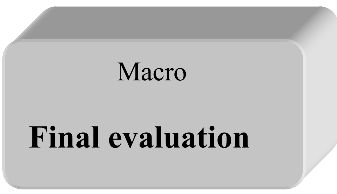
Aircraft type	Failure rate	Flying hours costs	No-failure operation	Severability	Final mark
L – 200	3	4	3	4	3,5
Z – 142	1	2	1	1	1,25
Z – 42	4	1	2	2	2,25
Z – 43	2	3	4	3	3

Table 5. Final evaluation

Failure rate	Final mark
Z – 142	**1,25**
Z – 42	2,25
Z – 43	3
L – 200	3,5

Table 6. Criteria

Criteria	Weight of criteria
Failure rate	1
Flying hours costs	1
No-failure operation	1
Severability	1



5.2.2. Final evaluation according to all of criteria – the weight of criteria Flying hours costs has changed (Tables 7-11)

Table 7. Comparison of aircrafts

Failure rate	Flying hours costs	No-failure operation	Alert
Z – 142	**Z – 42**	**Z – 142**	**Z – 142**
Z – 43	Z – 142	Z – 42	Z – 42
L – 200	Z – 43	L – 200	Z – 43
Z – 42	L – 200	Z – 43	L – 200

Table 8. Setting of marks according to several criteria without weight of criteria

Aircraft type	Failure rate	Flying hours costs	No-failure operation	Alert	Final mark
L – 200	3	4	3	4	3,5
Z – 142	1	**2**	1	1	1,25
Z – 42	4	1	2	2	2,25
Z – 43	2	3	4	3	3

Table 9. Setting of marks according to several criteria with weight of criteria

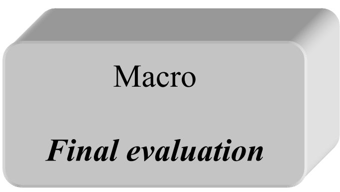
Aircraft type	Failure rate	Flying hours costs	No-failure operation	Alert	Final mark
L – 200	3	40	3	4	12,5
Z – 142	1	20	1	1	5,75
Z – 42	4	10	2	2	4,5
Z – 43	2	30	4	3	9,75

Table 10. Final evaluation

Failure rate	Final mark
Z – 42	4,5
Z – 142	5,75
Z – 43	9,75
L – 200	12,5

Table 11.

Criteria	Weight of criteria
Failure rate	1
Flying hours costs	10
No-failure operation	1
Alert	1



5.2.3. Final evaluation according to all of criteria – the weight of criteria Failure rate has changed (Tables 12-16)

Table 12. Comparison of aircrafts

Failure rate	Flying hours costs	No-failure operation	Alert
Z – 142	**Z – 42**	**Z – 142**	**Z – 142**
Z – 43	Z – 142	Z – 42	Z – 42
L – 200	Z – 43	L – 200	Z – 43
Z – 42	L – 200	Z – 43	L – 200

Table 13. Setting of marks according to several criteria without weight of criteria

Aircraft type	Failure rate	Flying hours costs	No-failure operation	Alert	Final mark
L – 200	3	4	3	4	3,5
Z – 142	1	**2**	1	1	1,25
Z – 42	4	1	2	2	2,25
Z – 43	2	3	4	3	3

Table 14. Setting of marks according to several criteria with weight of criteria Failure rate

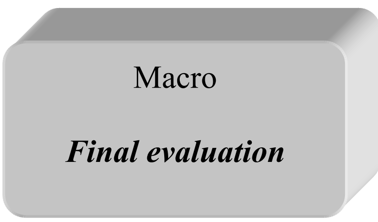
Aircraft type	Failure rate	Flying hours costs	No-failure operation	Alert	Final mark
L – 200	3	40	3	4	12,5
Z – 142	1	20	1	1	5,75
Z – 42	4	10	2	2	4,5
Z – 43	2	30	4	3	9,75

Table 15. Final evaluation

Failure rate	Final mark
Z – 142	3,5
Z – 43	7,5
L – 200	10,25
Z – 42	11,25

Table 16.

Criteria	Weight of criteria
Failure rate	10
Flying hours costs	1
No-failure operation	1
Alert	1



5.3. Computer results of expert system using at operators Žilina and SNA Bratislava

In the part 5.2.1 – **Final evaluation according to all of criteria – the weight of criteria is the same**, there are evaluated an **aircrafts** according to the next criteria:

failure rate evaluation,

flying hours costs evaluation,

evaluation of the no-failure operation expectation,

the ground alert evaluation.

I have made the sequence of the aircraft according to all of criteria (Table 2) and then I have assigned marks to each aircraft according to all of criteria (Table 3). In the Table 5 is Final evaluation for weight of criteria=1 for all of criteria.

The best was the aircraft Z 142.

In the part 5.2.2. **Final evaluation according to all of criteria – the weight of criteria Flying hour costs has changed,** there are evaluated aircrafts according to all of criteria (presented above). At first I have assigned marks to each aircraft according to all of criteria, I have made the Final evaluation without weight of criteria and then in the Table 10 there is the Final evaluation with the weight of criteria Flying hour costs=10.

The best was the aircraft Z 42.

In the part 5.2.3. **Final evaluation according to all of criteria – the weight of criteria Failure rate has changed,** there are evaluated the aircrafts according to all of criteria (presented above). At first I have assigned marks to each aircrafts according to all of criteria, I have made the Final evaluation without weight of criteria and then in the Table 10 there is the Final evaluation with the weight of criteria Failure rate =10.

In this case the best was the aircraft Z 42.

5.4. Software and Hardware Requirements for Expert System Realization

In the given research I have used programme tools of company Microsoft – objective oriented programming language Visual Basic and operating system Windows. Functions for calculating of individual criteria are executed in Excel using macros VBA and using macros are started all of comparisons and final evaluation of several aircraft types.

6. Conclusions

Expert system scheme is possible to use at operators of arbitrary devices that means in all the cases, when it is needed to compare several objects according to a lot of different and mutually inconsequent criteria. The user can choose arbitrary the evaluated objects count, the count of the criteria is eligible too, and weights are regulated according to neediness. In this case a suitable choosing of other models for examined characteristics calculating is important, as well as to choose such formulas and computing functions to realize them as simple as possible and input data to be available at operator.

It is possible to use it in diagnostics of devices. The user have to know some diagnostics methods that are allowed to use, the Basics of knowledge should be filled in with them.

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