Development and implementation of a knowledge acquisition methodology for seed material processing expert systems

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ABSTRACT

The work was aimed at realizing the problem of seed processing. Solving this problem it was ascertained that the existing mathematical methods are reliable enough, but they are used practically very seldom. The work offers to use the expert system technology which allows to solve problems connected with practical knowledge of experts in the region of investigation effectively. The method of knowledge structuring and analizing as well as technique of knowledge acquisition which is necessary for realization of this technology are worked-out in the work. As the result applying the worked-out method the prototypes of the expert system (ES) are created:

- ES "Sieves" : research prototype for the sieve choice for the seed sorting machines,
- ES "Diagnostics" : displaying prototype for the technological determination of action disrepair of seed sorting machines .

Key Word: expert system prototype, knowledge acquisition, seed sorting machines

INTRODUCTION

The main processes in the production of grain cultivation are the harvesting of grain-crops and processing of seeds after the harvesting. The gross output of grain-crops depends directly on these processes. The processing of seeds after harvesting is one of the most labour-consuming seed production processes. It includes different technologically connected operations in which sorting and cleaning of seeds are the most important. All the combine-harvested grain are subjugated to preliminary cleaning but after drying all the seeds and food grain are sorted. Cleaning and sorting the seeds special attention is turned to the action quality of seed sorting machines which depend on that how the machine is ready to act and input action regime. Therefore the working-out of theoretical questions and calculations on optimal action regime of the seed sorting machines are of great importance.

The optimal action regime of seed sorting machines is determined using the results of seed admixture analysis and experimental sorting if the three following problems have

been solved:
- the sieve cell' form, measures and optimal kinematic regime of the sieve mechanism are determined,
- the optimal air-current speed in pneumoaspiration canals is determined,
- the machine's optimal productivity which secures the given cleanness of basic fraction is determined.

Different methods are used to solve these problems. Each of them demands either great practical experience or enough profound knowledge of mathematics. To set action regime of seed sorting machines the operating staff uses the sieve choice tables. But these tables are formed for the standart conditions of seed humidity, measures and littering and therefore they allow to determine the necessary sieve cells' form and measures only approximately. Any deflection of seed showings from the standard demands modifications in the sieve cells' form and measures, otherwise the effect of segregating lowers. The user determines the optimal activity regime for the seed sorting machines basing on his experience and carrying out an experimental sorting. Besides it is necessary simultaneosly to alter sieve cells' measures, intensity of vibrations, sieve slope and air-current speed, all the time checking the cleaning of basic fraction. Obviously, because of the lack of experience of the operating staff, setting process can be long and this may cause baseless dissipation of the material. To use the expert system (ES) is one of the possible solutions of the problems.

MATERIALS AND METHODS

The research purpose - to work out the method of knowledge acquisition, to form ES prototypes in sieve choice and in technological determination of action disrepair of seed sorting machines in all the technological line stages of the seed processing. Because of technological disrepairs of seed sorting machines the user often cannot achieve the optimal action regime of the machines irrespective of the chosen sieves. Then it is necessary to analise the disrepair and to elicit the ways of their elimination.

Working out ES prototypes the knowledge acquisition is one of the main tasks. The term "knowledge" is considered to be all the information necessary for the problem solution. Traditionally the data obtained from expert are changed into rules or another forms. The result is difference between the expert knowledge and its encoding in software.

In the work the process of knowledge acquisition is regarded to be a process consisting of three stages: elicitation, analysis and processing. The elicitation is work directly connected with the knowledge acquisition from the expert. In the analysis' stage the conceptual model of problem is determined "Breuker and Weilinga (1987)". The further interpretation of elicited data is in the processing stage. At the stage of processing the worked out method of structuring of knowledge is proposed "Arkhipova and Rivzha (1994)". It consists of five stage: the formation stage of the AND-OR tree of variants, the formation stage of the context tree, the formation stage of the decision tree, the formation stage of rules, the formation stage of the conclusion tree.

At the formation stage of the AND-OR tree the expert must single out the objects that are essential for the given problem and give them conventional names. In turn, the totality of possible meanings must be defined for each object. At the first level of the hierarchic AND-OR tree lie the peaks-objects, but at the second level - peaks-meanings. Among the second level peaks can be both peaks-meanings and peaks-objects in which the initial object is divided. Peaks can be AND-peaks that contain alternative objects or their meanings characterizing individual features of each object. Although AND-OR tree structure is hierarchic, it does not always depict full coherence of problem objects, because the object hierarchy can be both functional and constructive. In case of the functional coherence not always it is possible to determine hierarchy by the means of the formal knowledge. For achieving this target the context tree must be formed basing on expert knowledge.

The context tree can be interpreted as a succession of subproblems in which the initial problem is divided by the help of the method understood for the user. The peak of the context tree is the target of problem, meanings of which are to be determined in the decision process.

The following steps are performed in the formation of the decision tree:

- seeking for decisions in the AND-OR tree of variants among all the possible AND-OR trees stating all the admissible AND-trees. Admission is determined basing on expert knowledge about the peak coherence in a separate AND-tree,
- giving the expert - stated meaning to each admissible AND-tree which can be the decision of a problem. Each admissible AND-tree is formed in accordance with structure of the context tree. The meaning of the concrete problem decision peak - is added to each AND-tree,
- uniting all the subtrees with identical problem decision peaks-meanings, the decision tree is formed. The designed decision tree forms hierarchy of objects' peaks-meanings , in which the root peak is a problem target.

The formation of rules starts from the leaves of the decision tree. In the conditioned part of the rule the meaning of one peak-progeny is encoded in case their coherence is in OR-peak, or meanings of all peaks-progenies in case their coherence is in AND-peak. In the final part of the rule the meaning of the peak-progeny is encoded. The formulated rules form the knowledge basis.

The conclusion tree reflects the application sequence of the rules. Peaks of the trees are the rules which are coherent. Coherency determines the sequence of the rule conclusion.

Knowledge elicitation, as the process of analysing an expert task, is analogous to the process of system analysis where some system is analysed with a view to re-design or automation. The end result of elicitation is unarguably a representation of the expert task. The concrete techniques have been suggested for the task of knowledge elicitation. The techniques are used to structure the data associated with the expert task. In the **Table 1** the correspondence of the method stages of knowledge structuring with the techniques of knowledge elicitation is depicted.

RESULTS AND DISCUSSION

The worked-out method of knowledge structuring and the offered knowledge elicitation technique were used to plan the ES prototypes, which allow to find out the reason lowering the seed sorting quality. Due to technical disrepair of grain cleaners, irrespective of the choice of the sieve equipment, the user often cannot adjust the optimum labour regime for the machine. Then, it is necessary to analyse hindrances in the work and give a consultation on the ways of removing them. As a result of the investigation two prototypes of ES "Sieves" and "Diagnostics" were built "Arkhipova and Rivzha (1993)".

The consultation performance starts with the user's demand on purpose of sorting. The user puts the necessary data into the machine. Further the system depending on the user's answer asks about: the seed type, the seed and admixture form, ability to pour, the seed measures, the nominal pratuctivity of the machine, the amount of the segregated mixture and comes to conclusions about: machine type, structure of sieve mechanism, the sizes and forms of all sieve cells (Fig. 1).

In the testing stage the test samples which secure ES prototype "Sieves" checking were chosen. The consultations on each sorting type (7 variants), on seed type modifications (2 variants), seed form modifications (2 variants), admixture form modifications (2 variants), pouring modifications (2 variants), all in all 112 test samples. The result was formed as the ES "Sieves" knowledge basis and allows with the user's data to determine the following: the mechanism structure of concrete sorting machine sieves, sieve cells' measures and forms, sieves for a practical use.

The ES for technological determination of seed sorting machines "Diagnostics" is logically connected with the ES "Sieves". If in the dialogue with the ES "Sieves" inexact data are input and the sieve scheme is formed from the given data, the sorted seed quality will be bad. The seed quality may be also bad because of the seed sorting machine imperfection. The ES "Diagnostics" must be used to find out the reason lowering the seed sorting quality. When the user determines the disrepair reason the system will give a method eliminating it (Fig. 2). During the period of testing all kinds of disrepair testing were made.

CONCLUSION

The main results of the work:

- the knowledge basis of the sieve choice for seed sorting machines is created;
- the knowledge basis for the technological determination of seed sorting machines is formed;
- in the processing stage the formation method of knowledge structure is developed;
- the concreate technique of eliciting knowledge to analyse and process the knowledge further is selected;
- methodological support between the all stages of knowledge acquisition process is determined.

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Table 1. Correspondence of the method stages of knowledge structuring with the techniques of knowledge elicitation.

Techniques of knowledge elicitation	The method stages of knowledge structuring
Analysis of repertory grating	The formation stage of the AND-OR tree of variants
Analysis of repertory grating Analysis with still logical decision	The formation stage of the context tree
Observation Analysis of transactions	The formation stage of the decision tree The formation stage of rules
Questionnaring	The formation stage of the conclusion tree

Fig. 1. The decision example of the sieve choice problem.

The user's data :
name of seed - oats
seed length = 11.00
seed width = 2.80
seed thickness = 2.40
admixture form = round
seed form = oblong
purpose of sorting = seed material
the segregated mixture = 2%

The problem decision:
front frame = opened
seed deflector = is parallelly the upper sieve plane
bolt = shut
the sizes of all sieve cells :
the upper sieve plane - oblong, 2.44; 2.75; 3.05;
the middle sieve plane - round, 3.04;
the lower sieve plane - round, 2.43;

Fig. 2. The decision example of the technological determination task.

Disrepair : Bad seed separating quality

Reason : A large air-current speed in the aspiration canal

Kind : To slow down the air-current speed