Dairy Cattle Judging: An Innovative Application for Fuzzy Expert System

Hosein Alizadeh, Alireza Hasani-Bafarani, Hamid Parvin, Behrouz Minaei, Mohammad R. Kangavari

***Abstract*— Industrial livestock husbandry is one of the most important industries in the field of providing nutrients. Nowadays, many branches of the science are applied in this industry, like genetic which is employed for improving the race of cattle. This science tries to transport good features from current generation to the next. Many researchers have reported that there is a meaningful correlation between facial type (physical form) and production. So, type judging is one of the best ways for evaluating useful features. This assessment contains those features that have maximum correlation for producing milk. Fulfilling of the form related to type judging, named Unified Score Card, needs very much experiences and skills. A judge (human expert) does this uncertainly with regarding to his experiences and skills. In this paper, possibility of developing of an expert system for replacing human expert is investigated. Also, the knowledge extraction methods are described. Fuzzy logic is used for dealing with uncertainty. Finally, the knowledge representation methods are discussed and fuzzy rule base is proposed for representing this knowledge.**

***Index Terms*— Expert system, Fuzzy logic, knowledge representation, Dairy cattle, Type judging.**

I. Introduction

After agriculture industry, animal industry is the second most important requirement in the field of preparing of food. Industrial cow husbandry as one of the most important parts of this industry uses many sciences. Many researches show that type of cattle affects on economical age and producing of them [1-3]. Also, it has been shown that selection of cows, only in term of measure of producing milk, results in ligament falling which can cause much economical harm. Therefore, in the field of recognition of proper type, possessing adequate knowledge needs efficient management.

Livestock judging consists of making a careful analysis of animals, measuring them against a standard commonly accepted as the ideal. In the common parlance of livestock men, this ideal is called the type [4]. According to definition of Gillespie in [5], the "type" contains those visible physical aspects of body components that bases on facial judgment. Type judging is the procedure during that cattle type is evaluated with ideal or favorite type of the same race. To perform this evaluation, there are some predetermined criteria. These criteria fall into two general categories, qualitative and quantitative. Some of quantitative criteria such as length of body are measurable simply; however, some of them need human experience and knowledge [6].

In this paper a new approach based on expert systems is proposed to solve this problem. The proposed method for automatic type judging is quite general. The criteria used in type judging are based on linear approach. This approach can be used for any kind of cattle. Here, it is studied on Iranian Holestine cows [2]. In this paper, the measuring of possibility for designing such an expert system is studied.

The rest of this paper is organized as follows. In section II, the statement of problem and possibility of usage of expert system is discussed. Section III expresses the steps of designing the expert system for this problem. Subsection III.A evaluates the needed resource for designing such a system. The methods of extracting knowledge and representing knowledge in hardware level are described in subsection III.B and III.C. The subsection III.D proposes an inference mechanism for this knowledge. Section IV articulates answering the question, how the fuzzy logic can help to handling uncertainty? Finally, the conclusion and future works is discussed in section V.

II. Statement of the Problem

In this section, the dairy cattle problem, including 12 qualitative features is introduced, in detail. In addition, the possibility of developing an expert system for this problem is discussed both in technical and economical aspects.

A. Boundaries of the Problem

In the beginning of century 20, attempts were done for standardization in this field of animal husbandry. First, the Unified Score Card, USC, was defined in 1943 [5, 7]. The “good diary cows have common and certain features” is the basic idea behind designing of this card. This card can show

Manuscript received August 30, 2008.

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remarkable features of all races. In addition, it explains the features of ideal cattle and also their values.

The most important feature considered in cattle that have to be maintained and reinforced at the next generation is milky feature [12]. This feature has considerable correlation to facial type of animal. According to USC, 19 features of animal are determined and evaluated from 1-9. Among them, 12 features are qualitative which are valued according to expert's experience. Table 1 shows these features.

TABLE 1. THE 12 QUALITATIVE FEATURES OF THE HOLESTINE DAIRY COWS

Qualitative Features	
1. Chest width	7. Fore udder attachment
2. Loin	8. Suspensory ligament
3. Angularity(Dairyform)	9. Udder depth
4. Rear leg side view	10. Front teat placement
5. Rear leg rear view	11. Rear teat placement
6. Foot angle	12. Body depth

Our main aim is designing of an expert system for judging these 12 quantitative features.

B. Need to Human Knowledge

The main question for developing any expert system which must be answered at first is that "is there any need to human expert knowledge for solving the problem in non-expert system way?"

The last revision of the standards on USC card is performed at 1982 and no change is taken since that time [8, 9]. It is good to note that the evaluation procedure of the type judging is done just by human expert, so that the USC card only helps him. So far, any efficient automatic system is not designed.

Evaluation of qualitative features of dairy cattle is done according to experience of human expert and previous observations, completely. He creates hidden rules in his mind, according to his experience. Considering those hidden rules, he evaluates the qualitative features. This is one of the most important reasons for unsuccessfulness of the systematic methods and also previous attempts using classic software-based methods for solving the problem. It is obvious that the only solution which can model and solve this problem is based on expert's experience and knowledge. Yet, the automatic expert-based solution for this problem is not observed and this study is the first attempt to find that [10].

C. Justification of Using Expert System in Dairy Cattle Judging Problem

There are many reasons for justifying the usage of expert system for solving this problem.

As the first argument, any mistake in type judging directly affects on the next generation of the cattle and also on their features. Due to high sensitivity of this work, it is done only by human expert, until now.

Because of limited number of these experts, the type judging is very costly for animal husband. Also, performing this task for faraway animal husbands is very time consuming, too.

In addition, possibility of expert's mistake and un-controlling items during work is not negligible, and this can yield high cost.

As Durkin's definition of expert system in [11], if such a system exists, its response validity has to be at least equal to human expert. Since, such system can be developed using more than one human expert and some other knowledge resources, the response of the expert system will be more validated than a single human expert.

Also, the environment conditions like tiredness can affect on human expert; however, this is not for expert system.

Evaluating of update costs of expert system can also help in analysis of the justification of using such system. The most important aim of type judging is the race improving. Results of any race improvement will reveal after one generation. This period is about five years for the cows. Also, standards about type judging have not changed since 1982. It shows that the pace of science growing in this field is very low. In other hand, the rate of modification in the obtained knowledge is very low. Moreover, the adaptation time of this system is predictable. These results show that creation of such system is possible and economical in the case of adaptation cost of expert system.

As a brief, it can be concluded that developing an expert system for dairy cattle judging is justified, both in technical and economical aspects. Since, developing such system yields to more production and thus, many economical benefits, it can be done with the support of government.

III. DESIGNING THE EXPERT SYSTEM

Usually any kind of expert system can be designed in several steps. First, the knowledge for solving the problem is collected from knowledge resources, and then this knowledge is integrated. After that, the best method of knowledge representation in hardware level is selected. Finally, regarding to the nature of problem, an inference mechanism is determined [11].

A. Knowledge Resources

The first step for design of an expert system is always knowledge extraction [11]. For this work, several resources are used for knowledge acquisition. The most important knowledge resource in this study is human expert. Other knowledge resources are some literatures like [2, 4, 5] and also the web. Empirically, it can be said that the best and fastest of them is human expert.

B. Knowledge Extraction Methods

After detecting the knowledge resources, the knowledge extraction step is started which employs following methods. The first method is human perception from non-human resources. Content of the books [2, 5] and specially their materials like tables and figures can help to more perception about the knowledge. Also, a number of rules are implicitly said in some of them. As an example in [2], it is said that "In an animal, if the loin bends and the maze upwards, then the main judgment is on the loin; in other hand, its value would be less than five". Also, a part of this knowledge is extracted in the form of pictures. Fig. 1 is an instance of such kind of knowledge. In this figure, X is defined as the fuzzy variable for difference between loin and maze. In the rest of this paper, the knowledge extracted from non-human resources called knowledge 1.

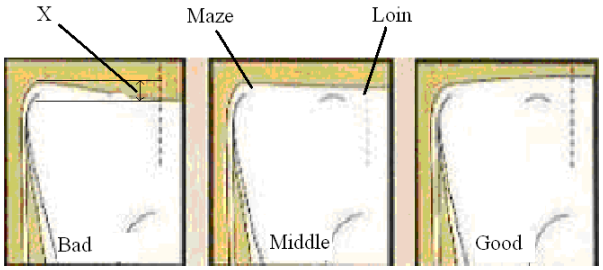

Fig. 1. The Loin feature, from left to right: whatever the height of loin is bigger than maze, it can achieve more scores.

Another method of knowledge extraction is interviewing with human expert. Since, the human expert has some hidden rules which are not explicit, the interview with the pre-provided forms to ask him, will appear his hidden knowledge, effectively. Fulfilled forms by human expert create a knowledge which is called number 2. This knowledge completes and revises the knowledge 1. One example of them is shown in table 2. The used linguistic variables in the forms are usually obtained from the non-human resources which are confirmed by human expert during the first sessions of interview.

TABLE 2. THE EMPTY PREPARED TABLE FOR EXTRACTING HUMAN EXPERT'S KNOWLEDGE WITH FUZZY VARIABLES

Fuzzy Variable (X)	Very lower	lower	A few lower	Almost the same	Upper
Score					

Event observation was the third method for extracting the knowledge. The knowledge extracted in this step is named, knowledge 3.

C. Knowledge Representation

Generally, knowledge representation methods have the following basic characteristics [11]. First, completeness which means that the represented knowledge must support all methods of inference. Second, compactness which means the knowledge must be stored briefly, in addition to completeness. Third, good performance which means that computing and using knowledge must be executable, without costly computation. Fourth, clearness which means that the behavior of knowledge must easily be understood and also its inference method must be clear.

It may be simplest and also the best way for expert system to infer according to the human expert's inference. Essentially, the human expert infers based on his hidden rules which he learnt, gradually. From knowledge 1, 2 and 3 can be understood that the knowledge is a collection of linguistic variables containing 12 features and their linguistic terms. It is obvious from our obtained knowledge and observations that this knowledge is naturally rule based. Rule base representation of knowledge is closest representation which can model this problem. Indeed, human expert decides based on the rules available in his mind. Knowledge 2 which is in the form of tables models this rules.

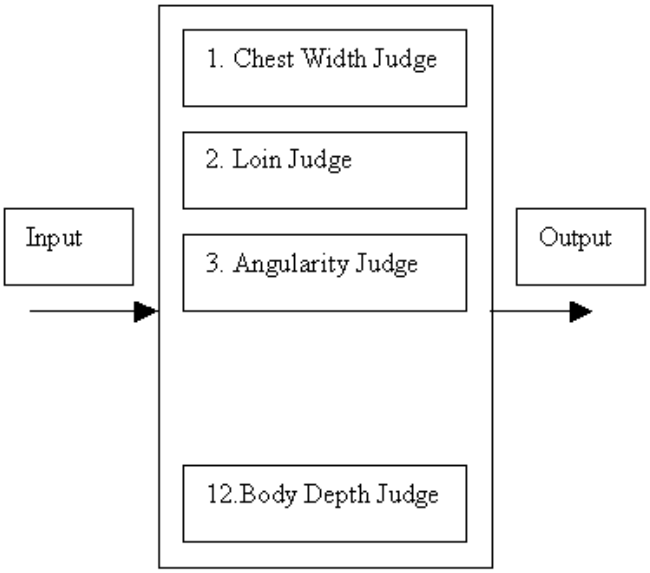

Fig. 2. The general structure of the proposed expert system

D. Inference Mechanism

From the collected knowledge, it is concluded that the human expert solves the problem separately for each features, regarding the inputs and parameters that are needed for each rule. It can be relatively easy for machine to pursue the human expert in this mechanism. It means that the problem is divided into 12 sub problems, and then each of them is solved, separately. Finally, to obtain the final solution of the main problem, the results are aggregated in backward mode. Consequently, the inference engine is activated by the problem in this system. It means that the problem causes to make observations. The simplicity and justifiability for clients are two measurements that must be considered for choosing inference engine method. These measurements are satisfiable by backward chaining mechanism; because this is the mechanism that human uses for solving this problem. In addition, this method can be easily depicted and also represented. Fig. 2 shows the general proposed scheme to design of the expert system for type judging problem.

Discussions in this section confirm the claim of authors that type judging of dairy cattle is such a problem which is completely matched to an expert system problem. All of qualitative features, linguistic and symbolic rules are qualitative parameters shows strong need for expert system.

IV. FUZZY RULE BASE

Existence of uncertainty and also many qualitative features in this problem can be a difficulty here. Naturally, the fuzzy knowledge is one of the best solutions to control and manage this uncertain features and parameters. Fuzzy logic is quite capable to represent the qualitative parameters by linguistic variables [13, 14]. Also, linguistic words which are used by human expert can be modeled and represented by linguistic terms [15, 16]. Table 3 shows the linguistic terms which are used in this expert system.

TABLE 3. THE FUZZY LINGUISTIC TERMS AND THEIR ABBREVIATIONS

vp	p	m	fg	g	vg	e
Very Poor	Poor	Medium	Fairly Good	Good	Very Good	Excellent

As a result, the final proposed expert system uses rule based knowledge and employs fuzzy logic for dealing with uncertainty. Table 4 shows the rule set for one of these features. The gray cell in table 4 represents a rule which means as follows:

// If (condition1) and (condition2) then (result);

If (chest-width is g) and (length-of-neck is m) then (out-strength is fg);

TABLE 4. THE FUZZY RULE BASE FOR CHEST WIDTH FEATURE CONSISTING TWO FUZZY VARIABLES: LENGTH OF NECK AND CHEST WIDTH

		Length of neck				
		vp	p	m	g	vg
Chest width	vp	vp	vp	p	p	fg
	p	vp	p	p	fg	fg
	m	vp	p	fg	fg	g
	g	vp	p	fg	g	vg
	vg	vp	p	fg	g	vg

V. CONCLUSION

In application areas of expert systems, usually the human experts are replaced with the expert systems. Expert systems solve the problem using human knowledge as well as using other knowledge resources. In this paper type judging of dairy cattle is introduced as a novel application of expert systems and the justification of developing expert system is discussed. Knowledge collection from knowledge resources and its representation in machine level is very important task to design the expert system which is also discussed for this problem. As the investigations in section 3, it is concluded that the best method for representation of the knowledge for this problem is rules. In addition, the backward chaining is proposed for inference engine mechanism, like the human inference method. Also, the fuzzy logic is proposed to solve the uncertainty problem. The proposed fuzzy expert system can handle the qualitative terms and variables. Because of the generality of proposed expert system, it is applicable to other non-dairy cattle, like horses and etc.

As a future work, using image processing techniques can improve this expert system in the case of obtaining inputs. These techniques can decrease the stress on cattle while measuring the inputs. Moreover, the machine learning techniques can be employed in this problem.

This study is the first attempt in this field. So, there is none available data set. This is one of the biggest difficulties facing in studying in this application. As the future work, one can start to collect a standard data set. However, any attempts for solving this problem in expert system way is not observed, this paper showed that “designing a fuzzy expert system for type judging of dairy cattle is completely practical and economical”.

ACKNOWLEDGMENT

Authors would like thank the officials of Jihad-e-Agriculture educational center of Tehran province (Shahid Zamanpour) for their assistance in providing necessary facilities for this research. This work is also partially supported by Data Mining Research group at NOOR Computer Research Center, Tehran, Iran.

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