# Fuzzy models for oestrus detection with dairy cows

DIMITAR RADEV, UNIVERSITY OF ROUSSE, BULGARIA
SVETLA TSONEVA VASSILEVA, UACEG - SOFIA, BULGARIA

**Abstract**

*Fuzzy models are used for oestrus detection with dairy cows. The influence of the number of terms of input and output linguistic parameters and the number of observed input parameters in oestrus detection are studied. The received models are estimated on the base of the target value and the maximal probability of oestrus detection.*

## 1 Introduction

There exist different methods for computer based oestrus detection with dairy cows in which, as significant parameters are used activity, milk yield, body temperature, milk temperature and feed intake. Last investigations shows that it is necessary to use more than one observed parameter for receiving representative results. Scholten et al. (1996) studied the possibility of using of fuzzy logic models for oestrus detection, based on the changing of the activity, milk yield and milk temperature. The fuzzy logic algorithm with 25 rules for automatic oestrus detection on the base of changing of the activity and milk yield are developed from Yang, (1998).

The practical use of these models in computer-aided management of the herd is connected with increasing of the degree of automatic detected cases of real oestrus and decreasing of the error value for wrong detected oestrus cases. In this investigation is suggested a solution of these problems with:

- Optimizing of the number of terms of the basic linguistic parameters and the rules for fuzzy interference;
- Optimizing of the number of input linguistic parameters.

## 2 Structure of the algorithm for oestrus detection

In this investigation is suggested a structure of the model for oestrus detection on the base of standard algorithms. The three main steps: fuzzyfication, fuzzy interference and defuzzyfication are realized with the help of the window *Projekteditor* of the program fuzzy TECH5.51. The algorithms of the input linguistic parameters are received from their membership functions (MBF), and the parameter „activity" is ranked in the interval from 0 to 4,0, and the parameter „milk yield" – from 0 to 2,0. The algorithm of the output parameter „oestrus" is executing on the base of the standard ??? method. The value of this variable is changing in the interval from 0 to 1. The terms of the linguistic parameters are changed on 3, 5 and 7, which are offered as a standard from the program. The received 6 variants: *oestrus3*, *oestrus5*, *oestrus7*, *oestrus53*, *oestrus73*, *oestrus75* are used for comparison of the fuzzy oestrus models (fig.1).

For the first three models the number shows the number of terms, which are divided symmetrical in the interval of changing for all linguistic parameters. For the rest three models the first number shows the input parameters number, and second – the numbers of the terms of output parameter. The fuzzy interference is realized with the help of regulating blocks RB, in which in matrix are defined IF…THEN rules. Their number depends of the number of terms of the model and is respectively for *oestrus3* – 9, for *oestrus5* and *oestrus53* – 25, and for the all rest - 49. The base of the oestrus detection of a cow is the output value of the defuzzyfication. The cow is in oestrus in the next cases:

- The output value is in term 3 for the models with tree terms of the output parameter;

- The output value is in term 4 or in term 5 for the models with five terms of the output parameter;
- The output value is in term 5, term 6 or term 7 for the models with seven terms of the output parameter.

The optimizing of the number of terms of the linguistic parameters is necessary and it is shown on the example, presented on fig.1, where the variants are studied with the values of input parameters, for „activity"equals to 1,8 and for „milk yield"equals to 1,1.
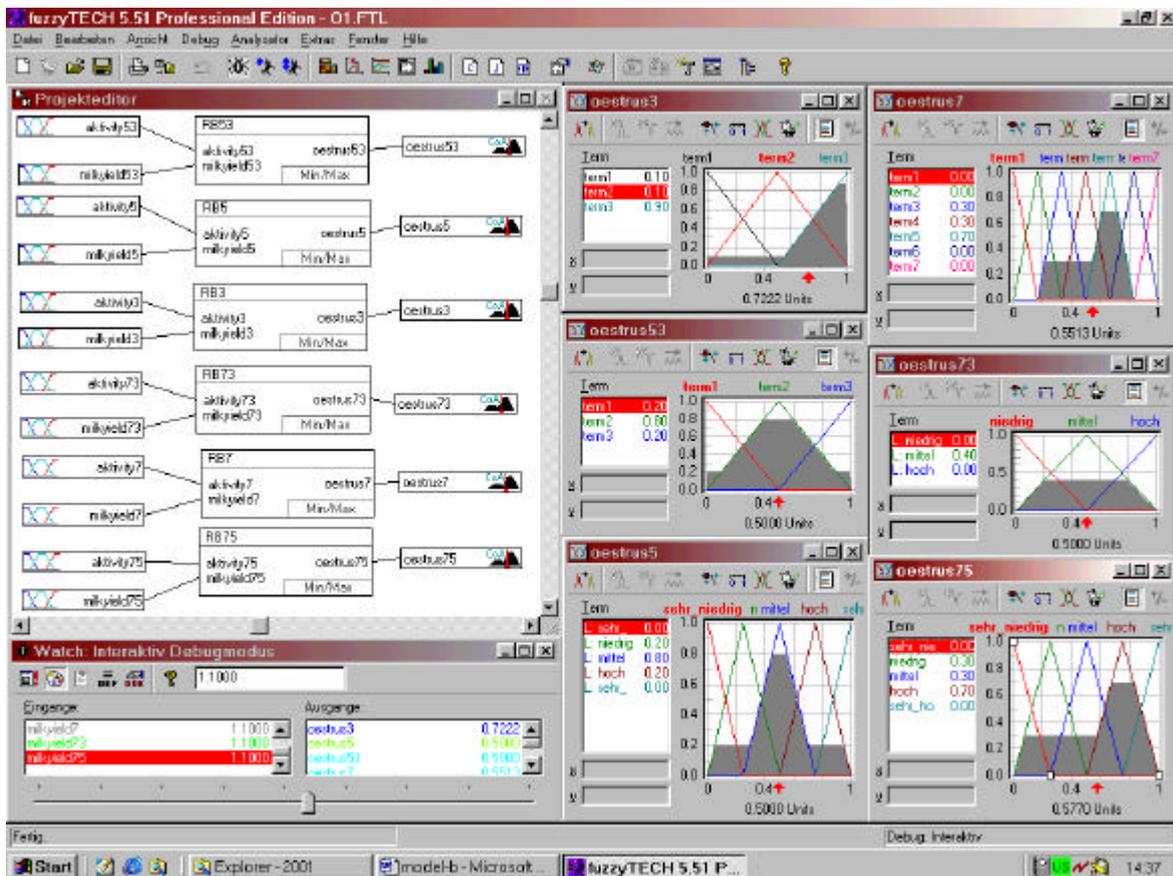


Fig.1. Comparison of fuzzy logic model for detection in different terms of the basis variables

The result of the comparative analysis is remissive. The output value is between 0,722 and 0,5, and for the three models (*oestrus5*, *oestrus53*, *oestrus73*) oestrus is not detected. Therefore, the right definition of the number of terms and their intervals is very significant for the accuracy of the model.

## 3 Examination and evaluation of the fuzzy logic model

For the model evaluation we investigated a herd of 24 cows (Holstein Frisian) total with 30 oestrus cycles. Each oestrus cycle duration continues seven days – four days before and three days after insemination. The data of the full activity are received with a device, described by Radev, (2000), and for milk yield – with the help of milk meter, mounted to the milking machine.

The target value and the error value are defined in the time as „a day before and in the day of the successful insemination" (Wendl and Klindtworth, 1997). Each oestrus is defined as a detected, if the probability for beginning of oestrus in the day of insemination or in the previous day has a place in the upper described cases. In this investigation for observed 30 cycles in 28 oestrus was detected. In connection with this the models are evaluated as in oestrus detection, so for detection of lack of oestrus.

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The second feature for evaluation of the models is their classification according to the number of reached maximal probability of each oestrus. For example, for „activity" = 3,4 and „milk yield" = 0,6 for all developed models is detected oestrus. The probability of oestrus appearance is different for the models: *oestrus3* – 0,667; *oestrus5* – 0,85; *oestrus53* – 0,8334; *oestrus7* – 0,8457; *oestrus73* – 0,8334; oestrus75 – 0,9167. The maximal probability is received for the model *oestrus75*.

Received results shows, that the maximal peak value for all models has very good level from 80 to 96% (see Fig. 2). The maximal level of the peak value is reached for model *oestrus7* and model *oestrus75* – 96,67%.
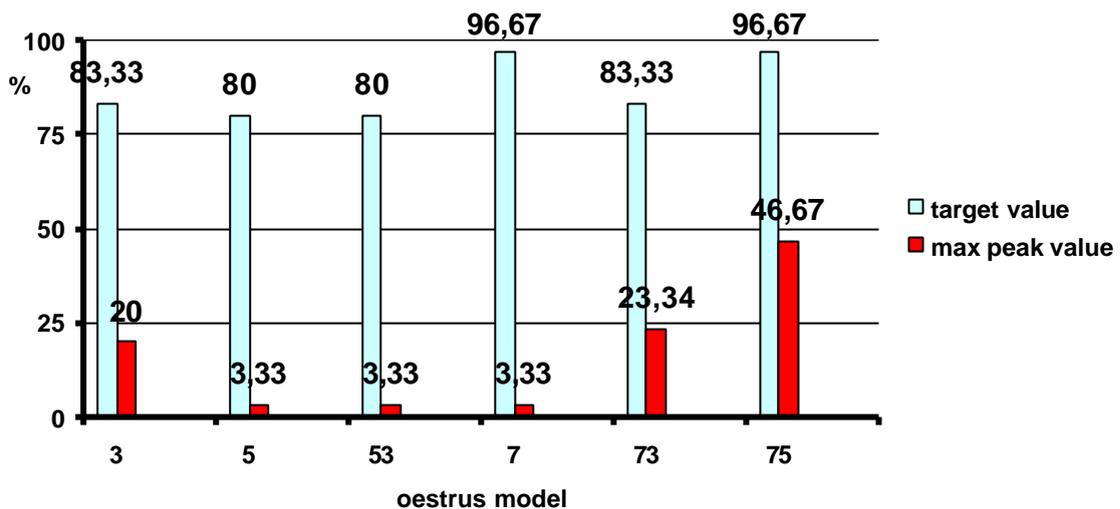


Fig.2. Influence of the number of terms on target values and max peak values of the oestrus model

According to the reached maximal probability the best results are received for the model *oestrus75* – 14 attempts or 46,67%. Good results are received for model *oestrus73* – 7 attempts or 23,34% and for model *oestrus3* – 6 attempts or 20%.

## 4      Comparison of models with two and three parameters

Other main problem, connected with the use of fuzzy models for early diagnostic of oestrus is the number of observed input parameters. For this purpose, the best of developed models, *oestrus75* was compared with a model, where as a third parameter was used milk temperature. In the received model *oestrus8*, presented on fig. 3 this new parameter was used as an additive, because his influence on the process of oestrus is weak (Scholten et all, 1996).

The model *oestrus8* has two terms – „low" and „height", ranked from 0 to 3. The rest input and output linguistic parameters are the same (as in the model *oestrus75*). In this model the fuzzyfication rules are twice more – 98, which increase the model accuracy.

In fig 3 is presented an example for „activity" =2, „milk yield" =1,3 and „milk temperature" =1,7. This is a boundary case for oestrus detection with the model *oestrus75* – the value is 0,525, term is equal to 3, or there is an error in oestrus detection. For the model *oestrus8* the probability of oestrus detection is higher – 0,7955 and has a place in term 4, that's why the result is classified as a positive. Therefore, the increasing of the number of input linguistic parameters leads to additional increasing of the model accuracy.
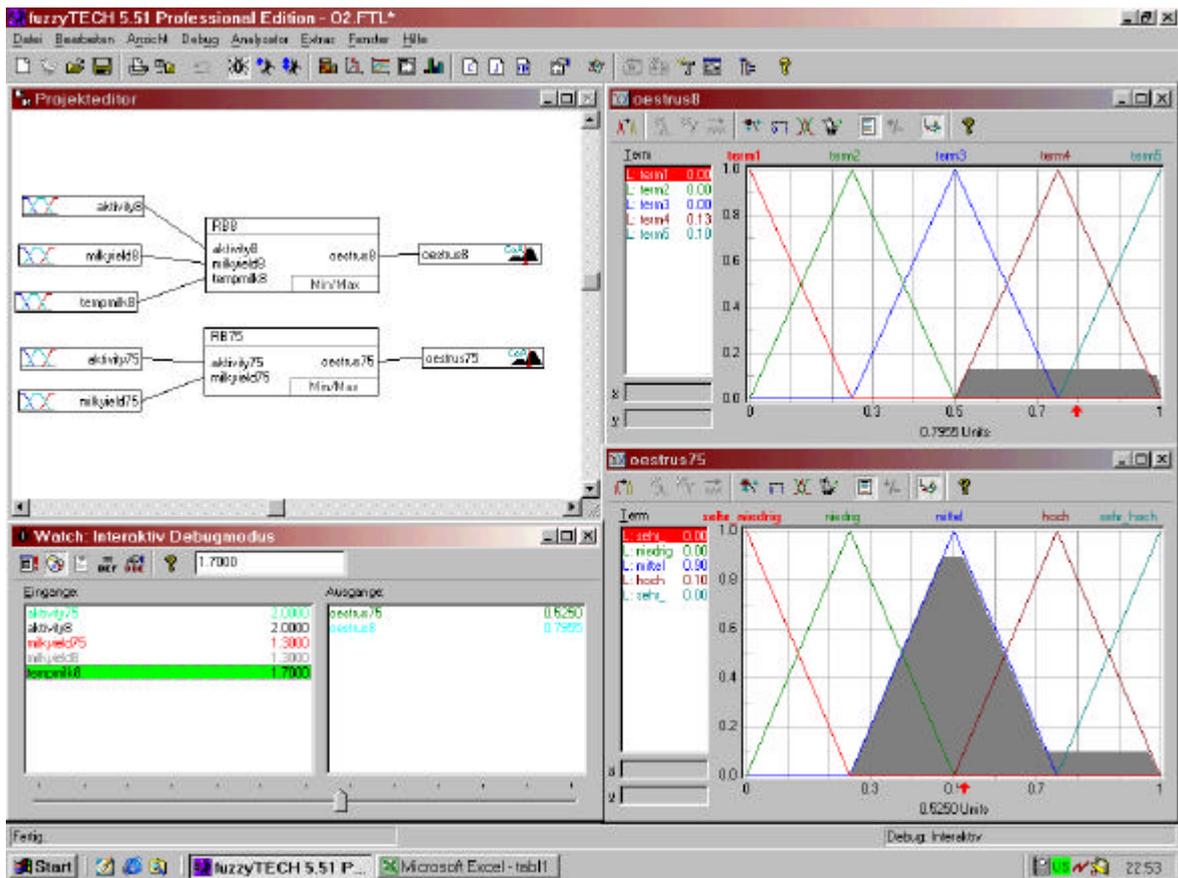
Fig.3. Comparison of the fuzzy logic models for detection with three or two input variables

## 5    Conclusions

The proposed method for oestrus detection with dairy cows on the base of fuzzy TECH5.51 gives a reason for the next conclusions:

- Increasing of the number of input linguistic parameters, and increasing of the number of their terms, leads to better fuzzy interference of the model, and to more full describing of the algorithms of the IF…THEN rules. In this way the target value increases (for the model *oestrus7* and the model *oestrus75* – more than 96%).

- Concerning to the number of terms of the output parameter better results were received for the cases of five terms (for the model *oestrus75* – the maximal peak value in 46,67% of attempts. In the cases with bigger or smaller number of terms can be reached uncertainty during the process of defuzzyfication of the model, which leads to decreasing of it accuracy.

## 6    Reference

RADEV D.; STOYANOV, I.; JAKOV, V. (2000): Automated electronic activity measurement for oestrus detection of dairy cows. Referate der 21 GIL- Jahrestagung in Freising – Weihenstephan, S. 158-161.

SCHOLTEN, H.; ERADUS, W.J. (1996): Oestrus detection in dairy cattle with an optimized fuzzy interference system. Proceed. of the ICSPAT. Voll. II, DSP Associates, Boston, pp. 1831-1835.

YANG, Y. (1998): Rechnergestützte Östrusüberwachung bei Milchkühen unter Anwendung der Fuzzy-Logik-Methode. Herbert Utz Verlag, München, Sh. 153.

WENDL, G.; KLINDTWORTH, K. (1997): Elektronikeinsatz in der Rinderhaltung – von der Identifizierung bis zur Automatisierung. FAT-Schriftenreihe Nr: 47, Tänikon, Schweiz, 101-112