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# RESEARCH REGARDING THE HUMIDITY AUTOMATIC CONTROL SIMULATION USING FUZZY LOGIC

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***Abstract:*** *This paper deals with humidity automatic control by an adjustment loop that uses Fuzzy Logic, which, in general, is avoided because this kind of control does not offer a quick output response depending on the input read values. Considering all this facts for humidity adjustment in warehouses for fruits and vegetables the humidity output can have delays without affecting the stored products quality or duration. From specialized literature the linguistically vocabulary that contains the proper storage humidity can be created easily. Regarding these arguments Fuzzy Logic adjustment loop can be used without any restrictions having the advantage of reduced energy consumption. The Fuzzy Logic simulation of humidity control was done in Matlab, simulation which shows how the automatic system adjustment loop works depending on the database which is created from data available specialized literature.*
***Keywords:*** *fuzzy logic, humidity adjustment, simulation.*

## 1. INTRODUCTION

The Fuzzy Logic tool was introduced in 1965 by Lotfi Zadeh, and is a mathematical tool for dealing with uncertainty. It offers a soft computing partnership the important concept of computing with words. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs such as “many,” “low,” “medium,” “often,” “few.” In general, the fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities [6].

On the contrary, the traditional binary set theory describes crisp events, events that either do or do not occur. It uses probability theory to explain if an event will occur, measuring the chance with which a given event is expected to occur. The theory of fuzzy logic is based upon the notion of relative graded membership and so are the functions of mentation and cognitive processes.

Fuzzy Logic control process in warehouses for fruits and vegetables consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

The most common shape of membership functions is triangular, although trapezoids and bell curves are also used, but the shape is generally less important than the number of curves and their placement. From three to seven curves are generally appropriate to cover the required range of an input value, or the "universe of discourse" in fuzzy jargon.

In this case the variable "humidity" can be divided into a range of states, such as: low, moderate, high, highest. Defining the bounds of these states is this Fuzzy Logic algorithm difficult part. An arbitrary threshold might be set to divide low from moderate, but this would result in a discontinuous change when the input value passed over that threshold[1],[2].

## 2. MATERIAL AND METHOD

The simulation was made in Matlab 2010 using FIS Editor Toolbox for creating the linguistically decision database. In this editor (fig. 1) were created the input and the output stages and also the rules that controls automatically the humidity level inside the warehouse cells. For this, from specialized literature, as input data there will be used the optimum values of the storing humidity for the main fruits and vegetables present in Romania [6],[7].

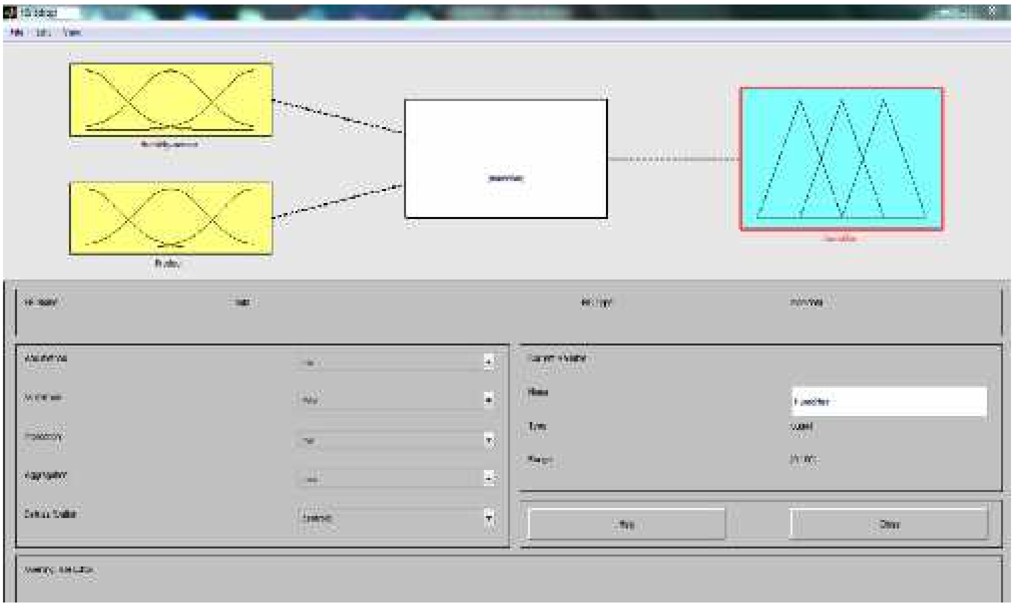

**Figure 1**: FIS Editor Toolbox

In Table 1 are presented these values and also the maximum storing period [3].

**Table 1**: Fruits and vegetables storage humidity

| Product | Air relative humidity , % | Maximum storage time |
|---|---|---|
| Blueberries | 90...95 | 2...3 months |
| Gooseberries | 85...90 | 1...4 weeks |
| Broccoli | 90...95 | 10...21 days |
| Apricots | 70 | 2...4 weeks |
| Early potatoes | 85...90 | 2...3 weeks |
| Late potato to consume | 88...93 | 4...8 months |
| Onions | 70...75 | 6 months |
| Cherries | 85...90 | 1...4 weeks |
| Cultivated mushrooms | 85...90 | 3...7 days |
| Green beans | 85...90 | 10...15 days |
| Quinces | 90 | 2...3 months |
| Kohlrabi | 90...95 | 2...3 weeks |
| Horseradish | 90...95 | 10...12 months |
| Peas | 85...90 | 1...3 weeks |
| Ionathan apples | 85...90 | 4...8 months |
| Golden apples | 85...90 | 5...6 months |
| Conference pears | 85...90 | 3...6 months |
| Carrots in links | 90 | 2 weeks |
| Carrots without leaves | 90...95 | 4...6 months |
| Green walnut | 70 | 1 year |
| Melons | 85...90 | 7 weeks |
| Watermelons | 85...90 | 2 weeks |
| Ripe tomatoes | 85...90 | 3...5 weeks |
| Celery | 90...95 | 0,5...2 months |
| Garlic | 70...75 | 6...8 months |
| Cabbage | 85...90 | 2...6 months |
| Brussels sprouts | 90...95 | 2...6 weeks |

The stored products that are in the warehouse and the humidity inside the warehouse cell which is read by the humidity sensors are introduced as input data. This system output is a signal unified in current intensity, 4...20 mA, send to the execution element which, in this case, is the humidifier. Afterwards the membership functions are created [4], [5].
In figure 2 are presented the curves of the input variable 'humidity'. These 3 membership functions are having the following values: dangerous between 0...45% , acceptable between 46...70% and optimal between 71...100%.

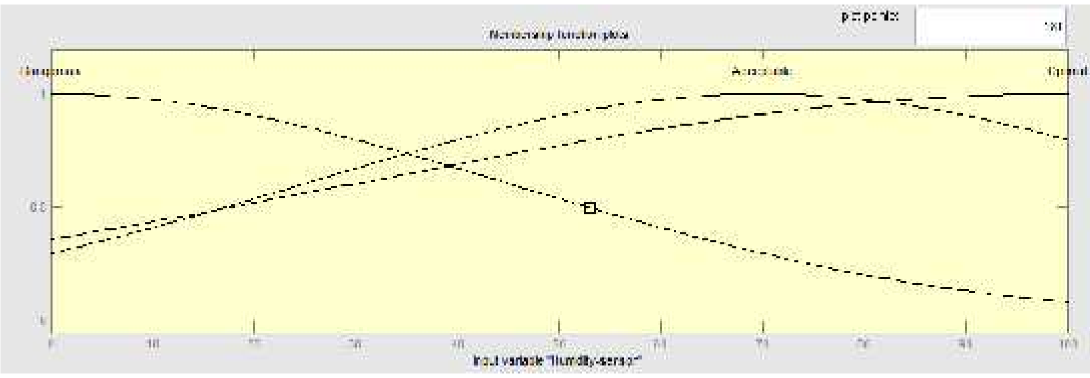

**Figure 2**: Input variable humidity membership function

For simplifying the hypothesis the fruits and vegetables were divided in 3 groups in according to their optimal storing humidity. So, Group 1 is formed from products having the optimal storing humidity between 70...80% , Group 2 between 80…90% and Group 3 between 90…95%. In figure 3 is presented the form of input variable product

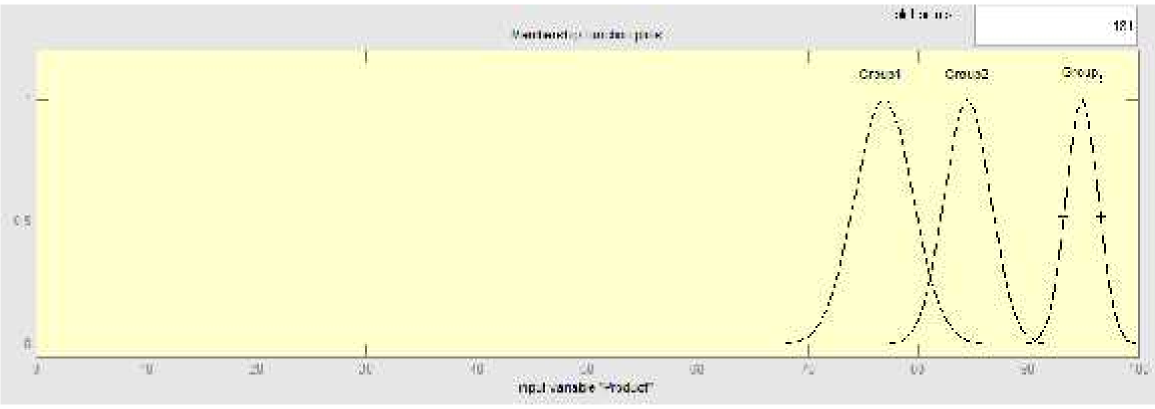

**Figure 3**: Input variable product membership function

In figure 4 is presented the output variable which is the humidity that must be introduced inside the warehouse by the humidifier. Depending on the humidity percent that must be increased inside the warehouse cells are created three degrees of functioning for the humidifier: small action for airflow with humidity situated between 0…20%; medium action for airflow with humidity situated between 20…65%; high action for airflow with humidity situated between 65…100%.

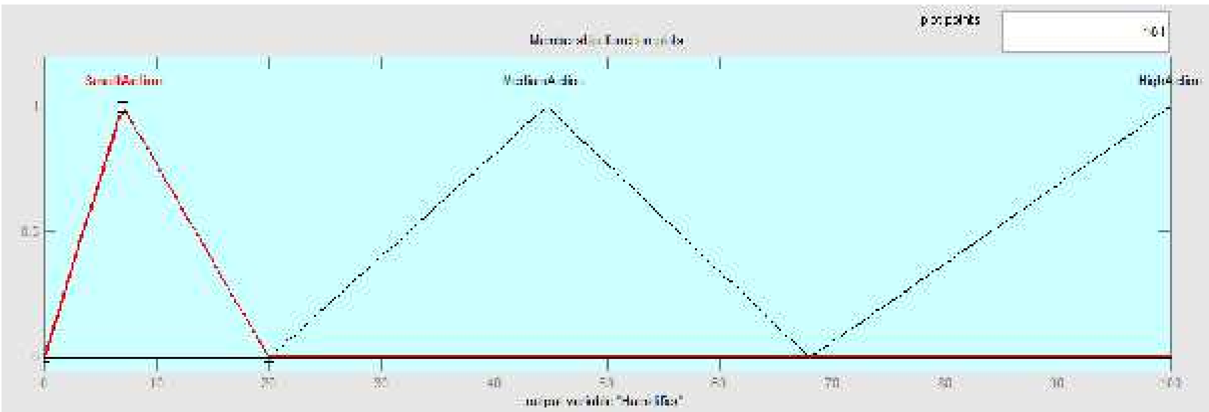

**Figure 4** : Output variable Humidifier membership function

After defining these 2 inputs and 1 output are created the rules that will assure this Fuzzy system correct functioning. These rules are:

1. If (Humidity is dangerous) and (Product is Group 1) then (Humidifier is HighAction);
2. If (Humidity is acceptable) and (Product is Group 1) then (Humidifier is MediumAction);
3. If (Humidity is optimal) and (Product is Group 1) then (Humidifier is SmallAction);

4. If (Humidity is dangerous) and (Product is Group 2) then (Humidifier is HighAction);
5. If (Humidity is acceptable) and (Product is Group 2) then (Humidifier is MediumAction);
6. If (Humidity is optimal) and (Product is Group 2) then (Humidifier is SmallAction);
7. If (Humidity is dangerous) and (Product is Group 3) then (Humidifier is HighAction);
8. If (Humidity is acceptable) and (Product is Group 3) then (Humidifier is HighAction);
9. If (Humidity is optimal) and (Product is Group 3) then (Humidifier is MediumAction);

## 3. RESULTS AND DISCUSSIONS

After defining all this Fuzzy Logic automatic control blocks the system is complete. For controlling this system it is offered a Toolbox where the system's inputs are introduced by the user (optimal humidity for the stored product), respectively by the humidity sensor that reads the warehouse cells humidity. With these two values the system automatically computes the output value that is send to the execution element. This output value can be seen in Figure 5. The 2 red lines from this figure can be moved. By moving them the product and the humidity value are modified and also a new computed humidifier is displayed.

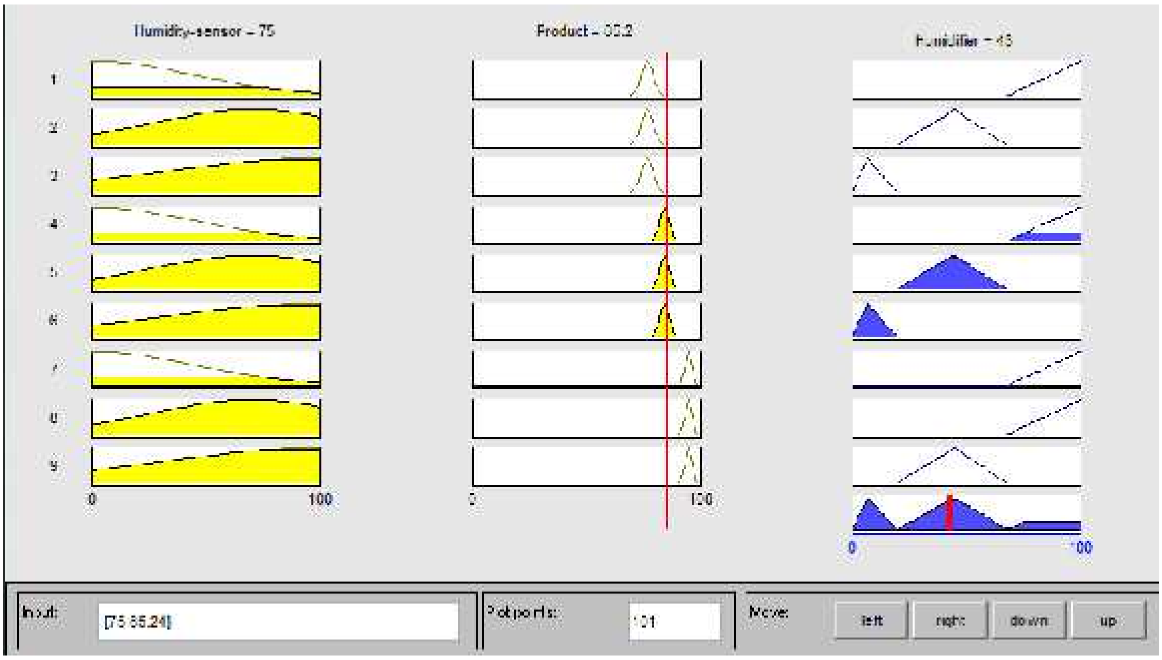


**Figure 5**: Inputs and output monitoring and control toolbox

For a more intuitive representation FIS Editor can create a picture (Figure 6) in which is represented the humidity automatic adjustment system  control surface view. This is the most effective way to see how the humidity control process works.

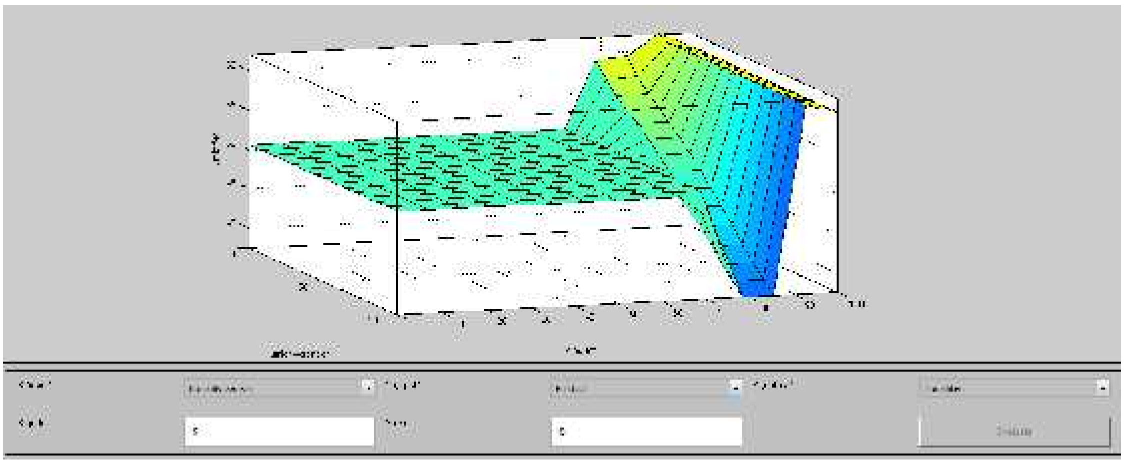

**Figure 6**: Humidity adjustment system - surface view

OY ax represent the humidity read by the sensors placed inside the warehouse cells, OX represents the optimal humidity corresponding to the stored product and on OZ represents the airflow humidity which is introduced inside the warehouse. It can be observed that this figure offers the possibility that according to the inside humidity and the optimal humidity necessary for stored products, the airflow humidity which is introduced into the storage room can be determined by the intersection of these three axes.

## 4. CONCLUSION

1. This computer simulation of humidity control illustrates the efficiency of this control algorithm, so by creating a single application the humidity can be controlled regardless the stored product. In fact, if is created a large data base it can be stored any kind of product, the user only concern being to choose the group that contains the respective fruit or vegetable
2. Nowadays due to the energetically crisis the use of Fuzzy logic can lead to energy efficiency comparing to PID automatic control algorithms. Especially in processes with high time latency the benefits of Fuzzy logic automatic control use becomes obvious.
3. The theory of fuzzy logic is based upon the notion of relative graded membership and so are the functions of mentation and cognitive processes. The utility of fuzzy sets lies in their ability to model uncertain or ambiguous data so often encountered in real life


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