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The Research on Intelligent Detecting of Greenhouse Environment for Cucumber Growth

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Abstract-Due to the complexity and changeableness of greenhouse environment, the growth environment of cucumber is difficult to detect. The data fusion is adopted to process the temperature, humidity and illumination to provide the detecting information. And for the disadvantage of the traditional Average algorithm which could not eliminate the drawback of the sensors in the data fusion, this paper uses the Fuzzy C-Means Algorithm(FCM) to fuse the data.The experimental results show that the FCM is better than Average algorithm in fusing the data. And the FCM improves the accuracy of the detection.

Keywords-greenhouse; data fusion; the Fuzzy C-Means Algorithm

1. Introduction

From the eighties, greenhouse facilities have a rapid development. The technology of greenhouse has broke through the constraints of the geography and climate .Greenhouse achieves the anti-season production[1]. Environmental control can not rely on manual operation because of the hostile greenhouse environment (high temperature, high humidity, etc.), therefore, it requires automatic control in the greenhouse environment.The detection system of greenhouse environment is an important part of automatic control. Many scholars had researched on how to obtain the detecting information of the greenhouse. In 1989, Japanese scholars Hashimoto proposed SPA (speaking plant approach) . The core of SPA is to use the imaging sensor on the greenhouse plants to carry out non-destructive detecting. Ting, Chun-Jiang Zhao and Xie Shouyong used the computer vision to get the information of plant growth[2][3].

This paper proposes a detection plan of the multisensors data fusion technology and expert system[4]. Due to the disadvantage of the traditional Average algorithm, this paper uses the Fuzzy C-Means Algorithm(FCM)[5][6] to fuse the data.

2. Expert Knowledge and data fusion

Based on expert knowledge, we classify the growth environment of greenhouse cucumber into three categories(suitable, more appropriate, not suitable).

The growth condition of greenhouse cucumber is shown in Tab.1.

TABLE.1 THE GROWTH CONDITION OF GREENHOUSE CUCUMBER

environment / factors	Suitab-le	more appropriate	not suitable
Temperature（T/℃）	18～30℃	10～18℃ and 30～35℃	less than 10℃ or more than 35℃

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Humidity（RH/%）	70～90%	60～70% and 90～95%	less than 60% or more than 95%
Illumination（L/klx）	20000~60000 klx	10000~20000 klx and 60000~70000 klx	less than 10 000 klx or more than 70000 klx

We use data fusion technology to process the environmental datas. Data fusion fuses the part of information obtained by the same or different types of sensors to describe things, and eliminates redundancy of the information,and improves the accuracy of Intelligent Systems Decision[7].

The processing of data fusion is shown in Fig.1 .

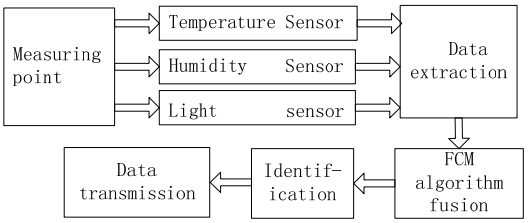

Fig.1 Schematic diagram of processing of multi-sensors information fusion

3. Proposed Fusion method based on FCM Algorithm

Sample set of greenhouse environment is : $X = \{x_1, x_2, \ldots, x_n\} \in R^S$; The feature vector $x_k = (x_{k1}, x_{k2}, \ldots, x_{ks})^T \in R^S$. x_k corresponds to a point of feature vector space. $x_{kj}$is the value of x_k on the J-dimensional. Greenhouse environmental factors is: $x_{k1}, x_{k2}, \ldots, x_{ks}$.FCM algorithm classifies the n-sample into three fuzzy groups, and solutes each of the cluster center to achieve the minimum non-similarity index of value function. The measurement data x_i belongs to the sensor i. The total of the membership of a data set is equal to 1.

$$\sum_{i=1}^{3} \mu_{ij} = 1 \text{ , } j \epsilon [1, n] \tag{1}$$

μ_{ij} is the data x_j belonging to cluster center c_i level.

Then, FCM's value function is the generalized form of the equation (1):

$$\begin{cases} J(U, c_1, \ldots c_c) = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c} \sum_{j}^{n} u_{ij}^m d_{ij}^2 & (2) \\ d_{ij} = \left\| c_i - x_j \right\| & (3) \end{cases}$$

$\mu_{ij} \in (0,1), m \in [1, \infty)$; c_i is the fuzzy cluster centers of group I; $d_{ij} = \left\| c_i - x_j \right\|$ is the euclidean distance between the cluster center of group i and the data of j; m is a weighted index.

Construct the new objective function and achieve the minimum necessary conditions of formula ③.

$$\begin{aligned} &\overline{J}(U, c_1, \ldots, c_c, \lambda_1, \ldots, \lambda_n) = \\ &J(U, c_1, \ldots, c_c) + \sum_{j=1}^{n} \lambda_j \left(\sum_{i=1}^{c} u_{ij} - 1 \right) \\ &= \sum_{i=1}^{c} \sum_{j}^{n} u_{ij}^m d_{ij}^2 + \sum_{j=1}^{n} \lambda_j \left(\sum_{i=1}^{c} u_{ij} - 1 \right) \end{aligned} \tag{4}$$

is the n-type Lagrange multiplier constraint of formula②. We derivate all the input parameters to reach the minimum necessary conditions of formula③.

$$\begin{cases} c_i = \dfrac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m} & (5) \\ u_{ij} = \dfrac{1}{\sum_{k=1}^{c} \left(\dfrac{d_{ij}}{d_{kj}} \right)^{2/(m-1)}} & (6) \end{cases}$$

FCM algorithm is a simple iterative process according to the above two necessary conditions.

Using the following steps solves the cluster centers c_i and attached to the matrix U.

Step 1: Initializing membership matrix U with the value of a random number between 0 and 1 to satisfy the constraints of formula①;

Step 2: Calculating 3 cluster center c_i with formula ⑤,i=1,2,3 ;

Step 3: Solving the value function with formula ② If the value of the value function is less than a determined value or the last value of the value function, FCM algorithm will stop;

Step 4: Calculating the new U matrix with formula ⑥and return to Step 2;

FCM algorithm can also be initialized cluster center, and then implementation of the iterative process. Performance of FCM algorithm depends on the initial cluster centers .Since we can not ensure that FCM algorithm converges to an optimal solution, we use another method to determine the initial cluster centers quickly or use different initial cluster centers to start the algorithm that is run several times.

The principle of the FCM clustering algorithm: Select large amounts of greenhouse environmental data as samples, containing suitable growth period, more appropriate growth period, not suitable growth period .Classify this historic data into three clusters(suitable cluster, more appropriate clusters, not suitable cluster). And adjust parameters of clustering algorithm. Then let the new data take part in clustering. If the number of new data samples were clustered into "suitable cluster", it indicates the growth of greenhouse environment suitable for cucumber.

4. Experiment

The data of Tab.2 is collected by the 10 sensors.

Number1 and number2 locate the entry position , number 3 and number 4 locate the left side of entry door, number 5 and number 6 locate the middle of greenhouse, number 7 and number 8 locate the left side of the tail, number 9 and number 10 locate the right side of the tail.

TABLE. 2 ENVIRONMENTAL FACTOR DATA

Site	Temperature (T/℃)	Humidity (RH/%)	Illuminati-on (L/klx)
1	15.5	73	16914
2	15.2	72	15500
3	16.4	71	13214
4	16.1	72	9653
5	20.7	62	20427
6	21.2	63	21016
7	9.1	42	2146
8	18.5	70	14026
9	18.2	66	17104
10	18.7	71	18438

(1)The average algorithm

Average greenhouse temperature is:T=16.96 ℃

Average greenhouse humidity is:RH=67.2%

Average greenhouse illumination is:

L=14843.8klx

The temperature ,humidity and illumination are not suitable for the growth of cucumber according to the average value.

(2)FCM algorithm

Most of the data were clustered into “Suitable cluster” from the table 3 and figure 2.

FCM cluster analysis algorithm is shown in Fig.2:

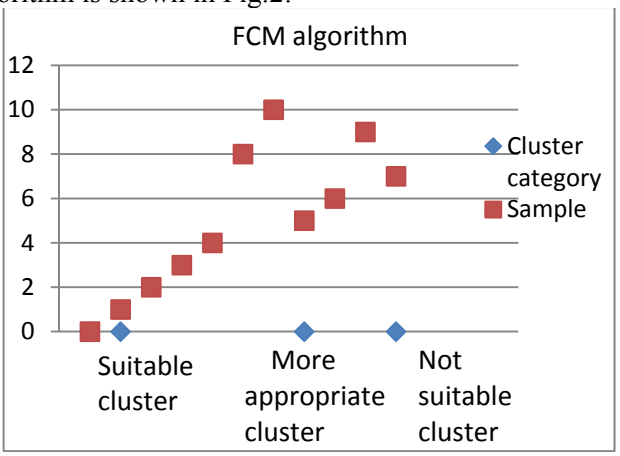

Fig.2 Schematic diagram of result of cluster analysis

TABLE.3 RESULT OF FCM CLUSTERING

Cluster category	FCM algorithm
Suitable cluster	3,4,5,6,8,10
More appropriate cluster	1,2,9
Not suitable cluster	7

It shows that the growth of greenhouse environment is suitable for cucumber.

(3)Compared with two algorithms

①Sensor 7 happens serious shortcoming form Tab. 2. Average algorithm does not remove the wrong data. But FCM algorithm clusters the wrong data into “Not suitable cluster”,which does not affect the results. Therefore, FCM algorithm does not have any impaction on the results even if some sensors have drawbacks.

②Remove the wrong data and use the average algorithm :

T=17.8 ℃;RH=69%;L=16254.6klx.

The temperature and humidity are not suitable for the growth of cucumber, and the illumination is appropriate for the growth environment of cucumber. But it is suitable for the growth of cucumber by using FCM algorithm. Therefore, The experimental results show that the FCM is better than Average algorithm in fusing the data.

5. Conclusion

Using FCM algorithm can improve the accuracy of detection, especially on the conditions of some sensors lose effectiveness in the system. System can obtain the information of greenhouse environment whether it is suitable for the growth of cucumber or not, according to other well sensors.

6. Acknowledgements

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