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Research Article

Climate Intelligent control in agricultural greenhouse

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Abstract – This document presents the agricultural greenhouse is a suitable place to control climatic factors and the requirements necessary for the proper growth of the plant. In this study aims to solve the problem of manual regulation of environmental conditions in greenhouses, using a new approach combining the methods (feedback and feedforward) and fuzzy logic controller. for the linearization and decoupling of our system.

Keywords – Decoupling, Nonlinear System, Meta Heuristic, Regulator (PID, PDF), Agricultural Greenhouse.

I. INTRODUCTION

This document represents the greenhouse cultivation is a world of intensive production which requires that production factors be maximized in order to ensure profitability. In all greenhouses, there are always periods during which the temperature, humidity, light and CO2 inside the greenhouse become extremely dangerous for the plant. This happens because of man's inability to make accurate and quick judgments. [1]

In our work, we are interested in climate control of the greenhouse. For this, we will develop the air conditioning model of a closed environment presented by "Daskalov and Arvanitis, 2005", it is non-linear and coupled in nature. To control air temperature and humidity simultaneously, we took models representing the main combinations between the biological and physical model of the greenhouse. The proposed method is applicable to any climate control device. [2]

The use of automatic regulation techniques made it possible to achieve technical and economic objectives by the producer such as:

-Increase the yield of agricultural production.

- Reduce energy consumption:

- Improve the quality of agricultural products.

- Production of vegetables and fruits in all seasons. - Remote control and management of the quantity and type of agricultural production.

II. ENERGY MODEL OF THE AGRICULTURAL GREENHOUSE

Our model is one-dimensional dynamic knowledge, which revolves around the formulation of the energy balances of the different components of the greenhouse (indoor air, plants, soil, heat exchanger). The latter is coupled and strongly non-linear with respect to temperature (Heating/Cooling) and humidity. These equations are defined as follows [3]

$$\frac{dT_{int}}{dt} = f_T(T_{int}, H_{int}, Q_{ch}, H_{Br,}V_{v,m}, Q_{PL}, V_{air}, T_{ext}, H_e) \quad (1)$$

$$\frac{dH_{int}}{dt} = f_H(T_{int}, H_{int}, H_{Br}, V_{v,m}, H_{PL}, R, H_{ext}, H_e) \quad (2)$$

$$\rho c_p v_t \frac{dT_{int}}{dt} = Q_{PL} + Q_{ch} + Q_R + Q_V + Q_C + Q_e + Q_{Br} \quad (3)$$

$$\rho c_p v_t \frac{dH_{int}}{dt} = H_{PL} + H_{Br} + H_{air,int} - H_{air,ext} + H_e \quad (4)$$

This model is non-linear and strongly coupled

With: [4]

ρ : Air density$[kg.m^{-3}]$, C_p: The specific heat of air $[J.kg^{-1}.K^{-1}]$, Q_{PL}: Heat produced by plant evapotranspiration [kW], Q_{ch} : The heat of the heating system [kW], QC, Qe, QBr , QV : Heat lost by the cover, water vaporization, fog system and ventilation system [kW], QR : The heat produced by the sun [kw], Tint : The temperature of the air inside the greenhouse [0C], Hint : The humidity of the air inside the greenhouse [%],HPL : The rate produced by plant evapotranspiration $[kg.h^{-1}]$, HBr : The water evaporation rate for the fog system [kg.h-1], Hair, int , Hair, ext , He : The rate of moisture transfer from outside air entering the room Greenhouse, Rate of humidity transfer from the indoor air leaving the greenhouse and the rate of evapotranspiration of water respectively [kg.h-1]

III. CONTROL BY THE PSEUDO-DERIVATIVE FEEDBACK

We have developed a control system for the operation of the greenhouse. A model of nonlinear thermodynamic laws between many system variables affecting the greenhouse climate has been formulated and a PDF controller is designed. The system was validated by simulation. The system's sensors and actuators behaved reasonably and responded quickly to changing conditions such as predetermined outdoor climate and indoor climate targets. [5], [6]

Thus, the system signal readings could be used as criteria for failures of actual sensors and actuators. Proper and timely monitoring and fault detection of sensors and actuators will contribute to the effective and efficient operation of the greenhouse. The desired responses can be described by the following models:

$$H_T(s) = \frac{e^{-d_T S}}{\tau_T S + 1}, \quad (5)$$

$$H_H(s) = \frac{e^{-d_H S}}{\tau_H S + 1} \quad (6)$$

τ_T, τ_HRespectively, are the desired time constants.

using the following approximations for the denominator exponential [7], [8]

$$e^{-d_T S} = 1 - d_T s \quad , e^{-d_H S} = 1 - d_H s \quad (7)$$

We obtained :

$$K_{D.T}(s) = \frac{\tau_T}{K_T d_T}, K_{I,T} = \frac{d_T+\tau_T}{K_T d_T(\tau_T+d_T)} \quad (8)$$

$$K_{D.H}(s) = \frac{\tau_H}{K_H d_H} \;, \quad K_{I,H}, = \frac{d_H+\tau_H}{K_H d_H(\tau_H+d_H)} \quad (9)$$

We obtained:

$$K_{D.T}(s) = \frac{\tau_T}{K_T d_T}, K_{I,T} = \frac{d_T+\tau_T}{K_T d_T(\tau_T+d_T)} \quad (10)$$

$$K_{D.H}(s) = \frac{\tau_H}{K_H d_H}, K_{I,H},= \frac{d_H+\tau_H}{K_H d_H(\tau_H+d_H)} \quad (11)$$

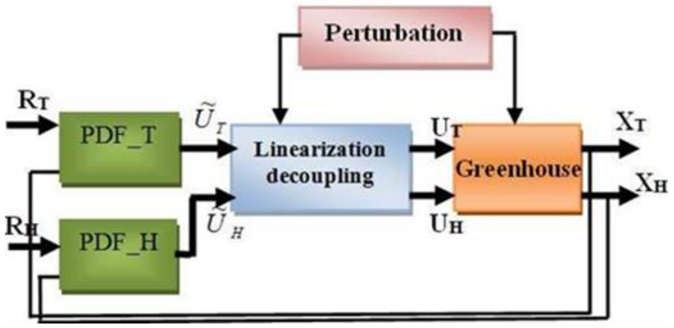

Fig. 1 Control strategy with PDF.

IV. CONTROL BY FUZZY LOGIC CONTRLLER (FLC)

we are interested in the modification and regulation of temperature and humidity inside the greenhouse with variable external conditions (Text and Hext)

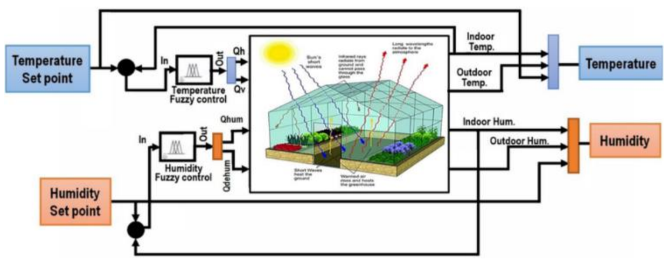

Fig. 2 Control strategy with FLC.

Table 1. Temperature membership matrix of a table.

Text / e	TF	F	PF	PT	T	PC	C	TC
NG	PC	PC	PC	PC	PC	PC	PC	AC
NP	PC	PC	PC	PC	PC	AC	AC	AC
EZ	PC	PC	PC	PC	AC	AC	AC	AL
PP	PC	AC	AC	AC	AC	AC	AC	AL
PG	PC	AC	AC	AC	AC	AC	AL	AL

Table 2. Humidity membership matrix of a table.

Hext / e	TS	S	PS	HA	PH	PH	H	TH
NG	PC	PC	PC	PC	PC	PC	PC	PC
NP	PC	PC	PC	PC	PC	PC	PC	PC
EZ	AC	AC	AC	AC	PC	PC	PC	AC
PP	AC	AC	AC	AC	PC	PC	PC	AL
PG	AL	AL	AL	AL	AL	AL	AL	AL

V. SIMULATION AND INTERPRETATION OF RESULTS

A. *Temperature regulation without change of set point TC=28°C*

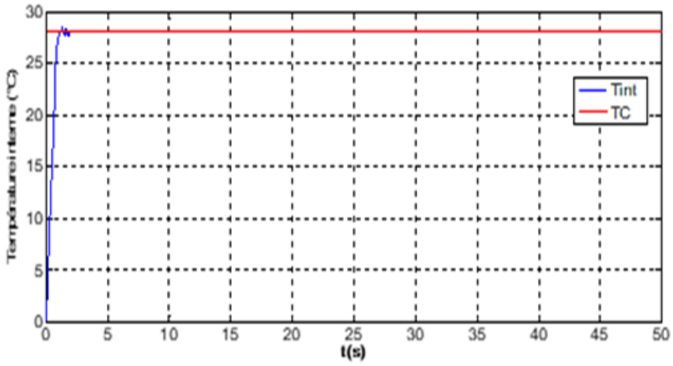

Fig. 3 Temperature adjustment without change of setpoint.

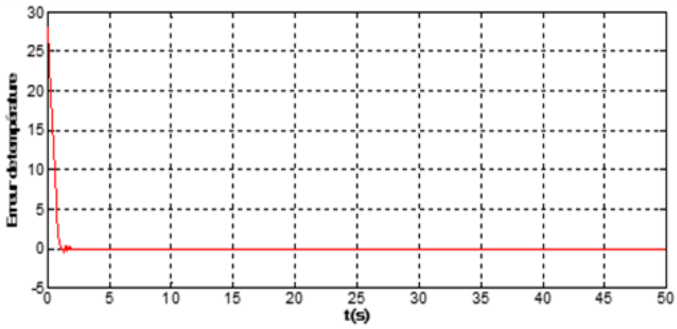

Fig. 4 Error.

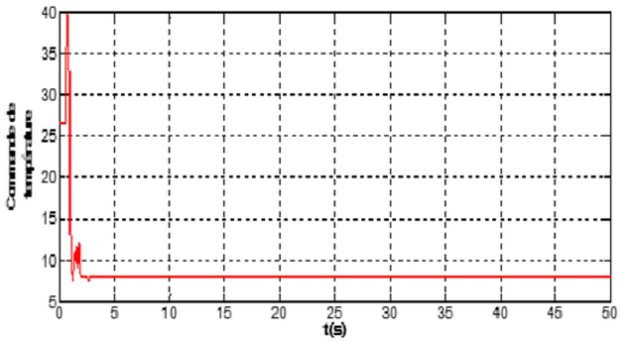

Fig. 5 Out put Controller.

B. Temperature regulation with change of set point

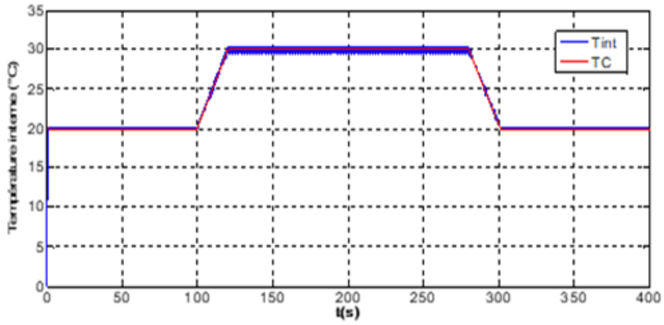

Fig. 6 Temperature adjustment with change of set point.

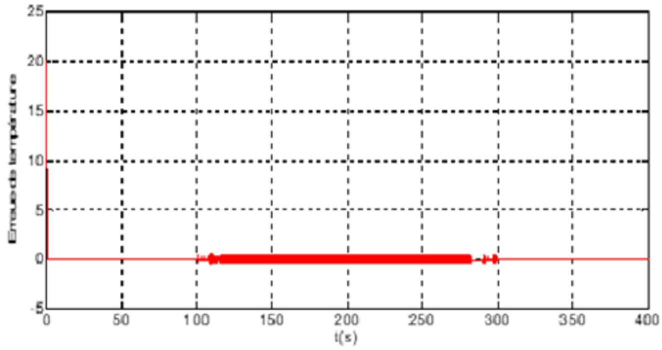

Fig. 7 Error.

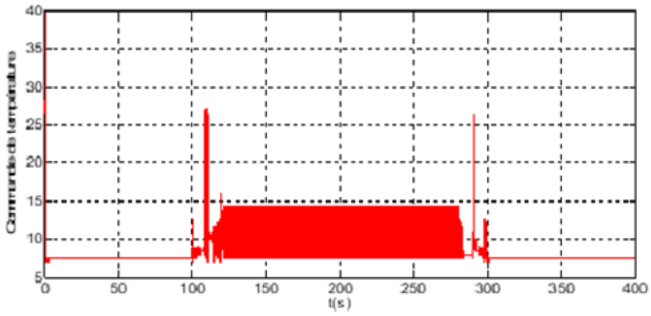

Fig. 8 Out put Controller.

C. Humidity regulation without change of set point HC=75%

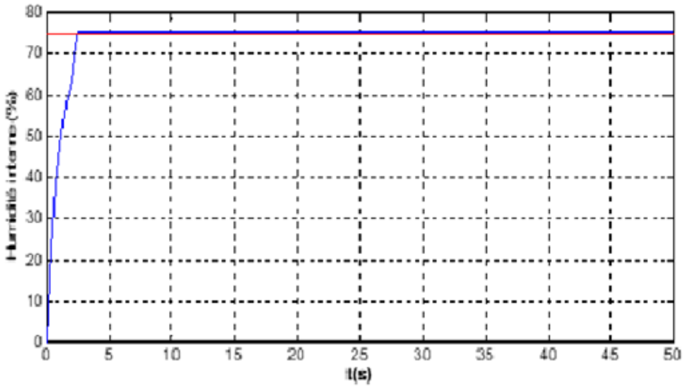

Fig. 9 Humidity adjustment without change of set point..

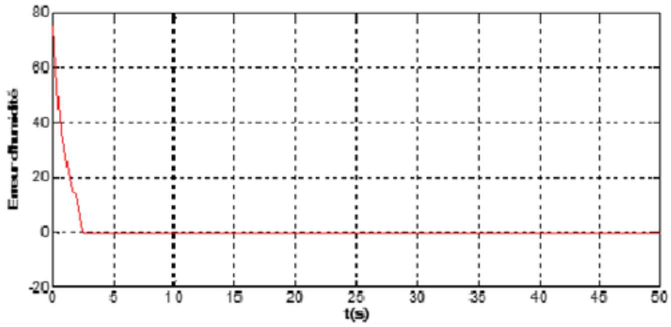

Fig. 10 Error.

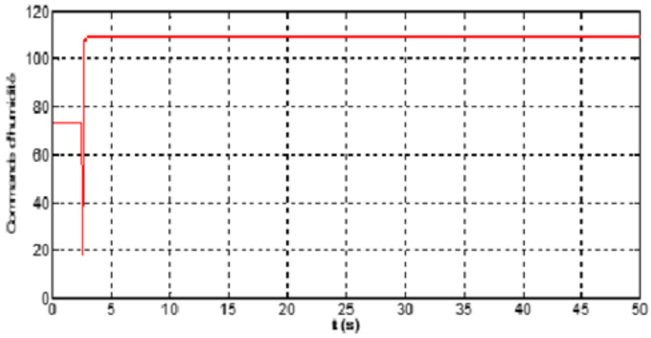

Fig. 11 Out put controller.

D. Humidity regulation with change of set point

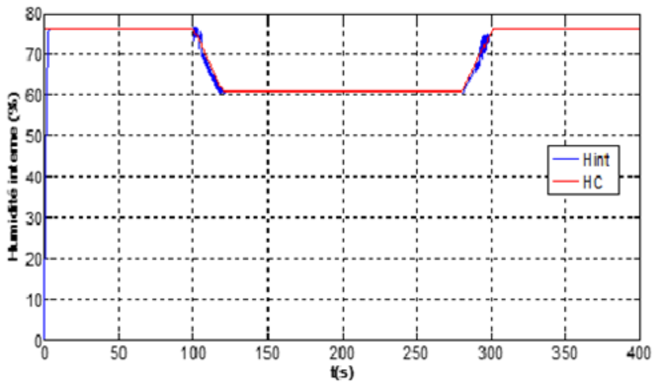

Fig. 12 C Humidity adjustment with change of set point.

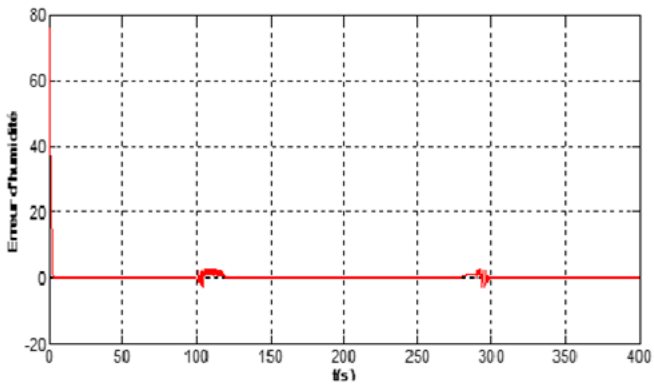

Fig. 13 Error.

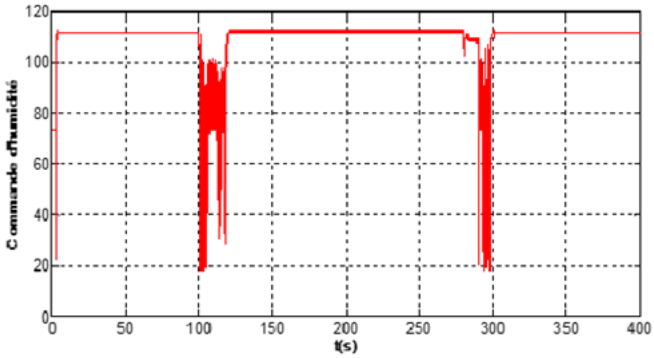

Fig. 14 Out put controller.

VI. DISCUSSION AND RESULTS

Our simulation of the greenhouse using fuzzy logic allows us to set two thresholds, one for temperature and the second for humidity. In our example, we have chosen as a setpoint a temperature of 28°C and a humidity of 75% with the external conditions being fixed: Text=32°C, Hext=82% and R=700Lux. For each figure, we noticed that the outputs (Tint and Hint) follow the desired setpoint very well with zero steady state error. But unfortunately these controllers do not respond to changes in external disturbances. With the same external conditions the response time found is as follows

- The temperature response time $t_T = 1.5\ s$.
- Response time for humidity $t_H = 2.5\ s$.

With the PDF regulator, we found the response time for temperature tT=30min and humidity $t_H = 38\ s$. The results clearly demonstrate that the speed of the system with the fuzzy controller is better than that of the PDF controller.

VII. CONCLUSION

The results closed-loop simulation are positive given that we were able to design the two fuzzy control regulators which manage the temperature and humidity regulation of our system with good precision. These results obtained after making modifications to the shape, distribution of membership functions and inference rules. The simulations suggest that the resulting control system is robust, stable, and responds adequately to external disturbances.

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