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Modeling a Fuzzy Logic Controller to Simulate and Optimize the Greenhouse Microclimate Management using MATLAB SIMULINK

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Abstract

The socio-economic evolution of populations has in recent decades a rapid and multiple changes, including dietary habits that have been characterized by the consumption of fresh products out of season and widely available throughout the year. Culture under shelters of fruit, vegetable and flower species developed from the classical to the greenhouse agro - industrial, currently known for its modernity and high level of automation (heating, misting, of conditioning, control, regulation and control, supervisor of computer etc ...). new techniques have emerged, including the use of control devices and regulating climate variables in a greenhouse (temperature, humidity, CO_2 concentration etc ...) to the exploitation of artificial intelligence such as neural networks and / or fuzzy logic. Currently the climate computer offers many benefits and solves problems related to the regulation, monitoring and controls. Greenhouse growers remain vigilant and attentive, facing this technological development. they ensure competitiveness and optimize their investments / production cost which continues to grow. The application of artificial intelligence in the industry known for considerable growth, which is not the case in the field of agricultural greenhouses, where enforcement remains timid. it is from this fact, we undertake research work in this area and conduct a simulation based on meteorological data through MATLAB Simulink to finally analyze the thermal behavior - greenhouse microclimate energy.

Index Terms: Greenhouse, Microclimate, Modeling, Fuzzy logic controller, Optimization, Simulation, Energy saving, Climate Model.

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1. Introduction

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

Increased demand and requirement of fresh products consumers throughout the year, led parallelly to a rapid development of agricultural greenhouse, which is today modern and quite sophisticated.

Agricultural greenhouse aims to create a favorable microclimate to the requirements of the plant, necessary for its growth and development, from the surrounding weather conditions. it produces based cropping calendars, off-season products, cheap and widely available along the year. [8]

It is defined by its structural and functional architecture, the optical quality, thermal and mechanical coverage and the accompanying technical means. it is considered as a very confined environment where many components are exchanged between them, and in which the main factor involved in this medium is light, temperature and relative humidity [7-9]. to manage the greenhouse microclimate, greenhouse growers often use methods such as passive static ventilation (opening), shade screens, evaporative cooling etc ... and occasionally the active type. these methods are less expensive but more difficult to manage and optimize [11-14].

The first objective is to improve the thermal capacity of the greenhouse (greenhouse).

This is, to characterize the behavior of the complex system that is the greenhouse with its various compartments (ground, culture, cover, indoor and outdoor environment). To develop non-stationary mathematical models usable for simulation, optimization and the establishment of laws and control of simple and effective regulation.

These models must reproduce the essential properties of the mechanisms and interactions between different compartments. they must be both specific enough to obey the dynamic and real behavior of the greenhouse system, and fairly small to be easily adaptable to the phases of the simulation.

Good modulation instructions depending on the requirements of the plants to grow under shelter and outdoor climatic conditions, result in a more rational and efficient use of inputs and equip the best production performance.

The greenhouse climate is modified by artificial actuators, thus providing the best conditions in the immediate environment of energy costs and it requires a controller, which minimizes the power consumption while keeping the state variables as close as possible optimal harvest. [16]

In this paper, or using fuzzy logic which is a powerful way to optimize and facilitate the global management of modern greenhouse, while providing through simulation interesting and encouraging which results in an optimization of favorable state variable values for the growth and development of protected cultivation [10-12-13].

2. Modeling the Greenhouse

This article deals with the modeling and simulation of our greenhouse model which is based on the method of GUESS. [1]

GUESS is a model set in parameter block, meaning that spatial heterogeneity is ignored and it is assumed that the inner content and the flow through the system boundary are evenly distributed.

The conservation equations are used to model the rate of system status change.

- ✓ For a warm greenhouse these state variables would be the indoor temperature, relative humidity, air pressure and CO_2 concentration.
- ✓ For the plant state variables are the water content, the body temperature, dry weight or biomass, and

internally sheet CO_2.

A complete equation for the transport of some scalar quantity through a control volume is as following:

$$CV\ \frac{\partial\Phi}{\partial x} = A(F_{int} - F_{out}) + V(Q_{source} - Q_{sink}) \quad (1)$$

C: The heat capacity (J / m^3. k).
V: System Volume (m^3).
Φ: is a quantity describing the state of the system (W / m^2).
dx: Material thickness (m).
A: The flow boundary surface (control surface) (m^2).
F_{int}, F_{out}: Internal and external flux (W / m^2).

2.1. Modeling the climate of the greenhouse systems

2.1.1. Cooling pad Model

In a greenhouse, evaporative cooling devices are used to reduce the temperature when the fan can not reach appropriate levels for optimal plant growth. In equipped greenhouses, cooling evaporation is the second part of the unrealized gain. Most evaporative cooling methods can be modeled as adiabatic cooling process; the minimum temperature and the achievable maximum vapor pressure is equal to the wet bulb.

The effectiveness of the typical tablet is about 85%. The heat loss rate depends on the fan speed.

$$H_{pad} = H_{out} + \eta_{pad}(H_{wb} - H_{out}) \quad (2)$$

$$T_{pad} = T_{out} - \eta_{pad}(T_{wb} - T_{out}) \quad (3)$$

$$Q_{pad} = \rho\, \dot{V}Fan\, C_P\ \ \eta_{pad}\, (T_{out} - T_{wb}) \quad (4)$$

η_{pad} : Pad efficiency.
T_{out} ,T_{wb} : The difference between the outside temperature and wet bulb (K).
C_P : Specific heat (J/kg.k).
ρ: Density (kg /m^3).
$\dot{V}$: fan speed (m/s).

2.1.2. Model of fogging system

The flow of steam and heat are determined through Ohm's Law and is as following:

$$\dot{e} = KA_{net}\,(VP_{sat}\ \ (T_{wb}\,[T_{air}, rh_{air}]) - VP_{air}) \quad (6)$$

$$q = \lambda\dot{e} \quad (7)$$

q: Is the heat transfer between the nebulizer and the air of agricultural greenhouse (W/m^2).

K: Global coefficient of heat transmission (W/m^2.k).
P_{sat}:Saturation pressure (Pascale).
P_{air}: Pression de l'air ambiant (pascale).
λ: Thermal conductivity (W/m^2.k).

2.1.3. Evaluation Model of the wall temperature T_p

The T_p wall temperature evaluation model **[8]**, closest to reality is determined based on the average temperatures T_{p_i} and T_{p_e}:

$$T_p = \frac{T_{p_i}+T_{p_e}}{2} \tag{8}$$

The indoor and outdoor temperatures T_{p_i} and $T_{p_e}$are:

$$T_{p_i} = T_{air,i} - \frac{K(T_{air,i}-T_{air,e})}{h_{p_i}} \tag{9}$$

$$T_{p_e} = T_{air,e} + \frac{K(T_{air,i}-T_{air,e})}{h_{p_e}} \tag{10}$$

The temperature evaluation model of $\mathbf{T_p}$ wall will be expressed:

$$T_p = \frac{T_{air,i} + T_{air,e}}{2} + \frac{k(h_{p_i} - h_{p_e})}{h_{p_i}.h_{p_e}}.\frac{T_{air,i} - T_{air,e}}{2}$$

$$T_p = \frac{T_{air,i} + T_{air,e}}{2} + C_B\frac{T_{air,i} - T_{air,e}}{2}$$

Where:

$$C_B = \frac{\lambda(h_{p_i} - h_{p_e})}{\lambda(h_{p_i} + h_{p_e}) + eh_{p_i}.h_{p_e}}$$

$T_{air,i}$, $T_{air,e}$: Dry Air temperature Inside / Outside (K).
h_{p_i}, h_{p_e}: Coefficient of superficial exchanges at the inter wall, of the outer wall (W/m^2.k).
C_B: Quotient de BIBI(.).

This report dimensionless C_B is used in evaluating the T_p wall temperature, it is now called the quotient of Bibi, it is the ratio of the difference of surface thermal exchange by conduction, convection and radiation occurring at the level of the greenhouse coverage.

2.1.4. Heating system

The heat produced per unit of fuel is modeled as:

$$h_{\substack{combution\\ sensible}} = LHV + \lambda\phi * \left[\frac{36}{16}\,\phi^{-1} - e_{sat}\,(T_{exhaust})\right] - (1-r)C_{P,air}\,T_{exhaust} \tag{11}$$

$h_{\substack{combution\\ sensible}}$: sensible heat load of a condensing water heater (J), LHV: is lower heating value (KJ/kg),
Φ: is the fuel air , 36/16: is the weight ratio of the produced steam to supply the burner, $T_{exhaust}$: is the temperature of the exhaust gas (k) and r is the return ratio.

2.2. Energy balance of the greenhouse

The analytical energy balance equation of the greenhouse:

Stored energy change = Gain from internal sources+ Gain from the sun - Losses due to conduction through the cover - Losses due to long wave radiation - Unrealized losses (evaporation) - Losses due to the exchange of air.

$$\overbrace{\rho_{air}\,V_{GH}\,C_{P,GH}\,\frac{dT_{in}}{dt}}^{\text{STORAGE}} =$$

$$\overbrace{\underbrace{\alpha_{SW}\,\tau_{glass}}_{\substack{Shortwave\\ Solar}} I + Q_{heaters} + \underbrace{\frac{r_{conv,out} + r_{cond,cover}}{r_{conv,in} + r_{cond,cover} + r_{conv,out}}\lambda K_{cond} A_{cover}\,[VP_{in} - VP_{sat}(T_{cover})]}_{Condensation}}^{GAIN}$$

$$-\overbrace{\underbrace{h_{r,sky}\,(1-\varepsilon_{cover})(T_{in} - T_{sky}) - 08\varepsilon_{cover}\,h_{r,cver}\,(T_{in} - T_{cover})}_{longwave} - \underbrace{A_{floor}\,\eta_{utilization}\,\frac{\Delta R_{net}}{\Delta + \gamma}}_{Evapotranspiration}}^{LOSSES}$$

$$-\overbrace{\underbrace{\left[\frac{1}{r_{conv,in} + r_{cond,cover} + r_{conv,out}} A_{cover} + P_{floor}\,(U\ell)_{perimeter}\right](T_{in} - T_{out})}_{conduction}}^{LOSSES\ CONT}$$

$$-\overbrace{\underbrace{\lambda K A_{net}\,(VP_{sat}\,(T_{wb}\,[T_{air}, rh_{air}]) - VP_{air})}_{Foggers}}^{LOSSES\ CON} - \overbrace{\underbrace{\rho C_{(P,air)}\,\dot{V}_{inf}\,(T_{in} - T_{out}) - \rho C_{(P,air)}\,\dot{V}_{net}\,(T_{in} - T_{pad})}_{advection}}^{LOSSES\ CON}$$

e_{sat} : Indicates the report saturated with the relative humidity in the sub-model of combustion (Kg steam / kg air).
$Q_{heaters}$: Is the heat provided by the heating system (W).
$r_{conv,in}$, $r_{conv,out}$: Heat transfer coefficient inside and outside by convection (W/m^2.k).

2.3. The mass transfer in the greenhouse

The mass balance for moisture in the greenhouse can be written as following:

$$\rho_{air} V_{greenhouse} \frac{de_{in}}{dt} = -\dot{V}_{inf} * \rho_{air} (H_{in} - H_{out}) - \dot{V}_{vent} * \rho_{air}(H_{in} - H_{pad}) + \underbrace{\frac{1}{\lambda} A_{floor} \eta_{uilization} \frac{\Delta R_{net}}{\Delta + \gamma}}_{Evapotranspiration} - \underbrace{K_{cond} A_{cover} [VP_{in} - VP_{sat}(T_{cover})]}_{condensation} + \underbrace{KA_{net}(VP_{sat}(T_{wb}[T_{air,} rh_{air}]) - VP_{air})}_{foggers} + \underbrace{r\phi e_{sat}(T_{exhaust}) \frac{Q_{heat}}{h_{combustion}}}_{combustion}$$

$\dot{V}_{inf}$: The speed of air infiltration (m/s).
$V_{greenhouse}$: The total volume of agricultural greenhouse (m^3).
H_{in}, H_{out}: Is the indoor and outdoor humidity (KJ / kg).
$\dot{V}_{vent}$: Ventilation rate (m^3 air / s).

And for the humidity balance:

Rates of change in absolute humidity = Infiltration + Ventilation * (humidity difference with the outside) + Misting + Cooling + AND - Condensation

The status of humidity function is:

$$\frac{dH_{in}}{dt} \underbrace{= -nV_p(H_{in} - H_{sat})}_{Ventilation\ infiltration} + K_{foggers}(VP_{in} - VP_{sat,wetbulb}) - K_{condensation}(VP - VP_{sat}) + \underbrace{E}_{Evapotranspiration} \quad (12)$$

$\underbrace{E}_{Evapotranspiration}$: The amount of heat provided by evapotranspiration (W).

Mass balance for CO_2 is:

$$\rho_{air} V_{greenhouse} \frac{100}{29} \frac{dC_{co_2\ in}}{dt} = -\rho_{air} \frac{100}{29} (\dot{V}_{inf} + \dot{V}_{vent})(C_{co_2\ in} - C_{co_2\ out}) \pm \dot{F}_{photosynthesis} + \underbrace{r\zeta \frac{100}{MW_{fuel}} \frac{Q_{heat}}{h_{combution}}}_{combustion} \quad (13)$$

CO_2 Mass Balance in molar units (ppm or μmol CO_2 per mol air). ζ is the number of moles of carbon per mole of fuel

$\dot{V}_{inf}$: Ventilation rate (m^3 air/s).

$\dot{F}_{photosynthesis}$: The amount of heat supplied by photosynthesis (W).

2.4. Photosynthesis

Photosynthesis is a complex process. CO_2 fixation and subsequent conversion into carbohydrates are not a single reaction, but a series of steps, the Calvin cycle (see diagram below). [2]

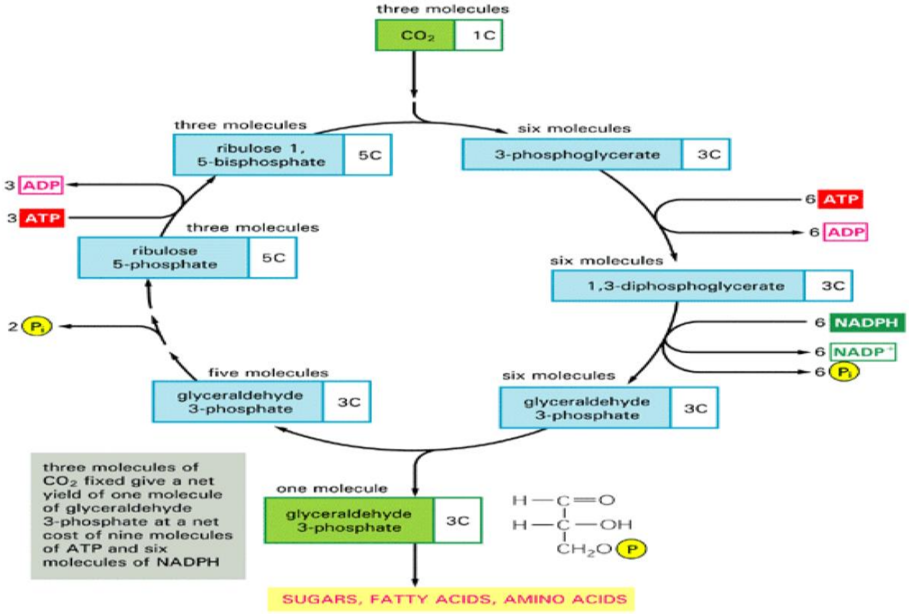


Fig.1 Schematic Calvin cycle. The reaction at the apex (CO_2 fixation and RuBP) is catalyzed by the enzyme Rubisco. this reaction ordered carbon assimilation rates, and that is modeled by Farquhar. al. equations. Source: Cellupedia, "Calvin cycle.

According to Farquhar model, the CO_2 compensation model is:

$$P = \left(1 - \frac{\Gamma}{C_i}\right) * min\{W_c\ , W_j\} \tag{14}$$

C_i: Internal CO_2 concentration (ppm).

2.5. Plant state of water balance

$$C_{PLANT} \frac{d\psi_{plant}}{dt} = \frac{(\psi_{soil} - \psi_{plant})}{R_{root} A_{root}} - E \tag{15}$$

In the model of GUESS, we assume that the soil is well watered, so that the physiological effects of the state of water should be minimal, except in stomata.

ψ : the potential of water.
C_{PLANT}: Is the capacity of the plant (mole*m^2).
E: Is evapotranspiration.
A_{root}: The root surface (m^2).
R_{root}: The growth rate.

2.6. Stomatal conductance and balance CO_2

The rate of photosynthesis in the Farquhar model depends on the internal concentration of CO_2.
To determine the concentration of CO_2, a mass balance is performed on the sheet.

$$C_{leaf}\frac{d[co_2]_i}{dt} = \frac{([CO_2]_e - [CO_2]_i) - P_{net}}{\frac{1}{g_{stomatal}} + \frac{1}{g_{aerodynamic}}} \quad (16)$$

According to GUESS the plant stomatal equation of is:

$$g_{stomatal} = min\left\{g_{closed} + m\left(\frac{rh_{leaf}P_{net}}{[CO_2]_{leaf}}\right) * \left(\frac{\theta_{soil} - \theta_{WP}}{\theta_{FC} - \theta_{WP}}\right), g_{open}\right\} \quad (17)$$

Ball-Berry modified model used in GUESS

$g_{stomatal}$: Is stomatal conductance in units of (mole.s^{-1}.$m^{-2.}$).

2.7. Plants Energy Balances

$$T_{leaf} = \frac{(1-\varepsilon_{cover})h_{r,sky}T_{sky} + \varepsilon_{cover}h_{r,cover}T_{cover} + g_{aerodynamic}T_{in} + \tau_{cover}I_{SW} + \lambda E}{(1-\varepsilon_{cover})h_{r,sky} + \varepsilon_{cover}h_{r,cover} + g_{aerodynamic}} \quad (18)$$

3. Fuzzy Controller Modeling

Fuzzy logic is widely used in the machine control. The term "fuzzy" refers to the fact that the logic can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". [15] While alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution can be cast in terms that human operators can understand, so that their experience can be used in the design of the control device. This makes it easier to mechanize the tasks have already been performed successfully by man [3]

3.1. Fuzzy inference method MAMDANI

Fuzzy inference Mamdani type, as defined for Toolbox fuzzy logic, expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable to defuzzification. It is possible, and in some cases much more efficient to use a single peak as output membership function, rather than a distributed fuzzy set. This is sometimes known as singleton output membership function, and we can think like a fuzzy set of pre defuzzification. It improves the efficiency of defuzzification because it greatly simplifies the calculation required by the more general method Mamdani which has the center of gravity of a two-dimensional function. [4-5].

To calculate the output of the SIF in view of inputs, six steps should be followed:

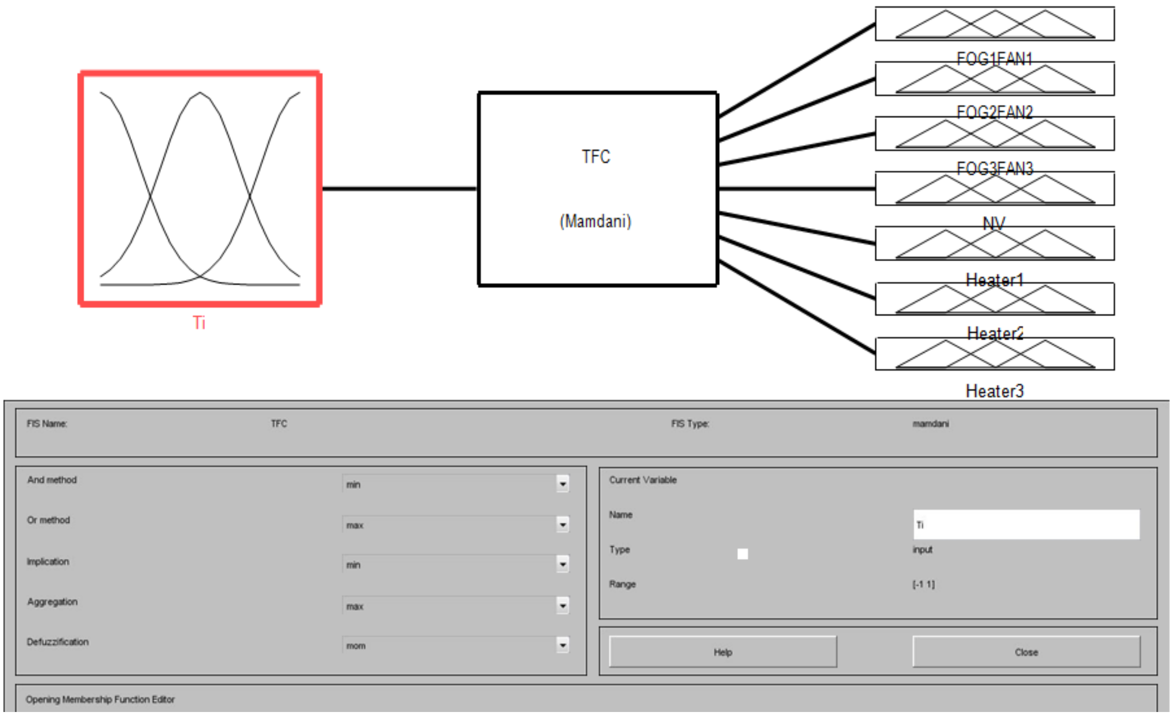
- ✓ The determination of a set of fuzzy rules.
- ✓ Fuzzification inputs using the input membership functions.
- ✓ By combining Fuzzificaion entries according to the fuzzy rules to establish a resistance to the rule.
- ✓ Find the consequence of rule by combining the resistance to the rule and the output membership function.
- ✓ By combining the consequences to get a distribution outlet.
- ✓ Defuzzification the output distribution.

3.2 Fuzzy Sets

The input variables in a fuzzy control system are generally mapped by sets of membership functions similar to it, called "fuzzy set". The process of converting a crisp input value to a fuzzy value is called "fuzzy logic". A control system may also have different types of switch, or "ON-OFF", inputs and analog inputs and during switching inputs will always be a truth value of 1 or 0, but the system can handle as simplified fuzzy functions happen to be one value or another. Given "mappings" of input variables membership functions and truth values, the microcontroller then makes decisions for action on the basis of a set of "rules".

3.2.1. Membership functions

The membership functions is shown in the following figure:



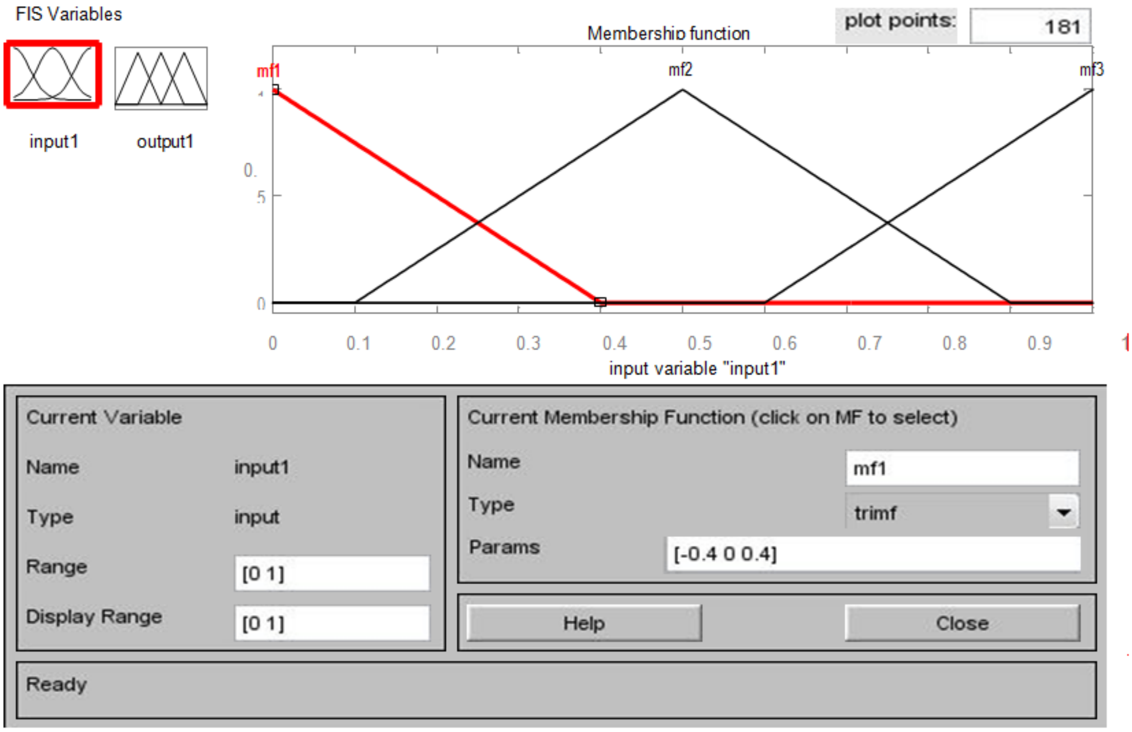


Fig.2. Representation rules of Membership Functions

3.2.2. Rules of decisions

- ✓ If (Ti is TVCOLD) then (FOG1FAN1 is OFF)(FOG2FAN2 is OFF)(FOG3FAN3 is OFF)(NV is OFF)(Heater1 is ON)(Heater2 is ON)(Heater3 is ON) (1)
- ✓ If (Ti is TCOLD) then (FOG1FAN1 is OFF)(FOG2FAN2 is OFF)(FOG3FAN3 is OFF)(NV is OFF)(Heater1 is ON)(Heater2 is ON)(Heater3 is OFF) (1)
- ✓ If (Ti is TCOOL) then (FOG1FAN1 is OFF)(FOG2FAN2 is OFF)(FOG3FAN3 is OFF)(NV is OFF)(Heater1 is ON)(Heater2 is OFF)(Heater3 is OFF) (1)
- ✓ If (Ti is TSH) then (FOG1FAN1 is OFF)(FOG2FAN2 is OFF)(FOG3FAN3 is OFF)(NV is ON)(Heater1 is OFF)(Heater2 is OFF)(Heater3 is OFF) (1)
- ✓ If (Ti is TH) then (FOG1FAN1 is ON)(FOG2FAN2 is OFF)(FOG3FAN3 is OFF)(NV is OFF)(Heater1 is OFF)(Heater2 is OFF)(Heater3 is OFF) (1)
- ✓ If (Ti is TVH) then (FOG1FAN1 is ON)(FOG2FAN2 is ON)(FOG3FAN3 is OFF)(NV is OFF)(Heater1 is OFF)(Heater2 is OFF)(Heater3 is OFF) (1)
- ✓ If (Ti is TEH) then (FOG1FAN1 is ON)(FOG2FAN2 is ON)(FOG3FAN3 is ON)(NV is OFF)(Heater1 is OFF)(Heater2 is OFF)(Heater3 is OFF) (1)

4. Simulation and Model Validation

Our model is based on the greenhouse GUESS model that is set for a multi greenhouse chapel which each module is 8.5 m wide, 34 m deep and ridge height of 4.5 m . Infiltration rate is 1.1 air changes per hour, and a

U value of 5.76 W / m^2.K was used. The model of the plant was set for Douglas seedling plants were started at 0.57 g dry weight, and harvested 1.67 g dry weight; a new growing season was recorded at harvest.

A set of hourly data for 2015 (1 January to 31 December) weather station of Dar El Beida Algeria [6], was used to validate our model as a CSV file that consists of four columns (global solar radiation, temperature, humidity and wind speed).

The model of the greenhouse was coded using the full version of Windows MATLAB R2012b (8.0.0.783), 64bit (win64) with Simulink. The simulation was performed on a Toshiba laptop. The laptop is equipped with a hard drive 700 GB and 5 GB of RAM. Simulink model of the parties were made in "Accelerator" mode that has first generated a compact representation of Code C of the diagram, then compiled and executed.

The simulation of our system was done by MATLAB SIMULINK. The results of the MATLAB / SIMULINK software indicate the high capacity of the proposed technique to control the internal temperature of the greenhouse even in the event of a rapid change of atmospheric conditions.

The modeling of the fuzzy logic controller is defined in the form of this block diagram:

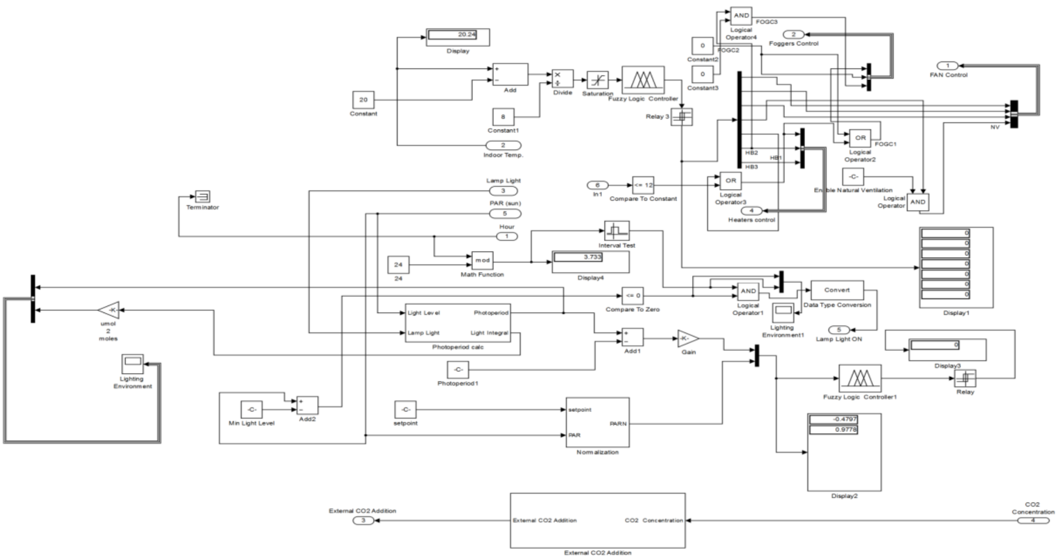


Fig.3. Schéma Simulink Représente Notre Contrôleur Flou

5. Results

The simulation results clearly visualize the actual thermo-energy behavior of agricultural greenhouse, applying the model of artificial intelligence, namely the application of fuzzy logic.

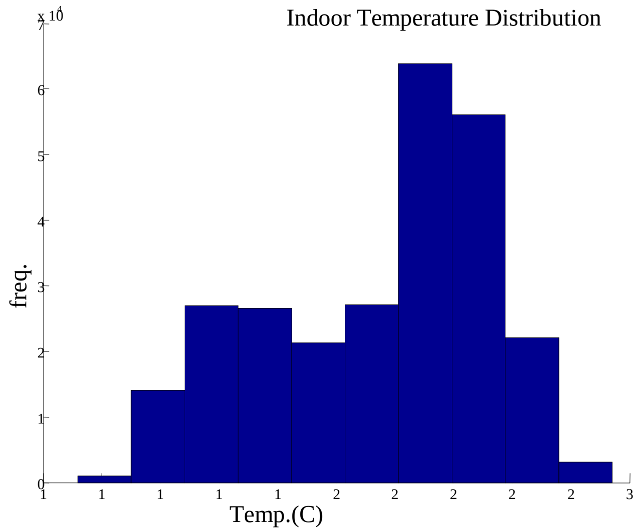


Fig.4. Histogram Shows the Distribution of Indoor Temperature

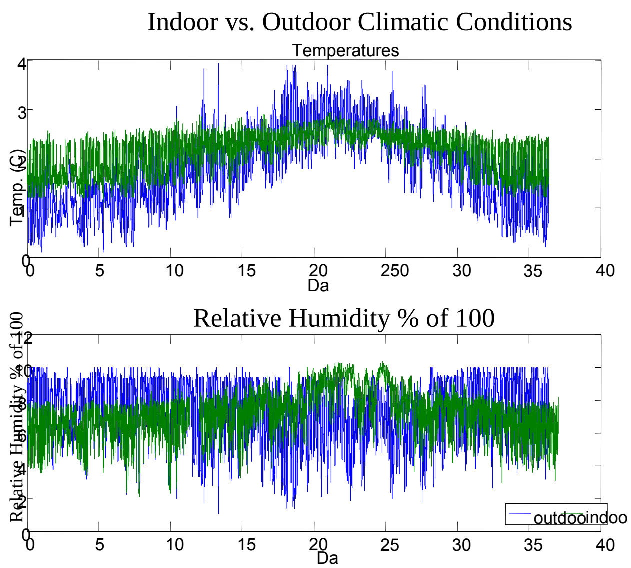


Fig.5. The Evolution of Humidity and Temperature (Interior / Exterior)

It is found that most of the internal temperature values are in the range 14 °C to 22 °C for autumn winter period and in the range 20 °C to 26 °C for the spring summer period in a large variation the temperature during the winter period is autumn due the heat loss at night, the compensation is insufficient by heating and expensive for this improved thermal insulation of the cover wall is necessary.

The improvement of the thermal isolation of the cover may be carried out in practice by the addition of an air bubble plastic layer assembled to the face interior of wall..

During the period spring summer the temperature is within the desired range.

The relative humidity is almost in the interval desired during all the year except at the few days of half of the summer because of the important vaporization used for the compensation of the temperature .

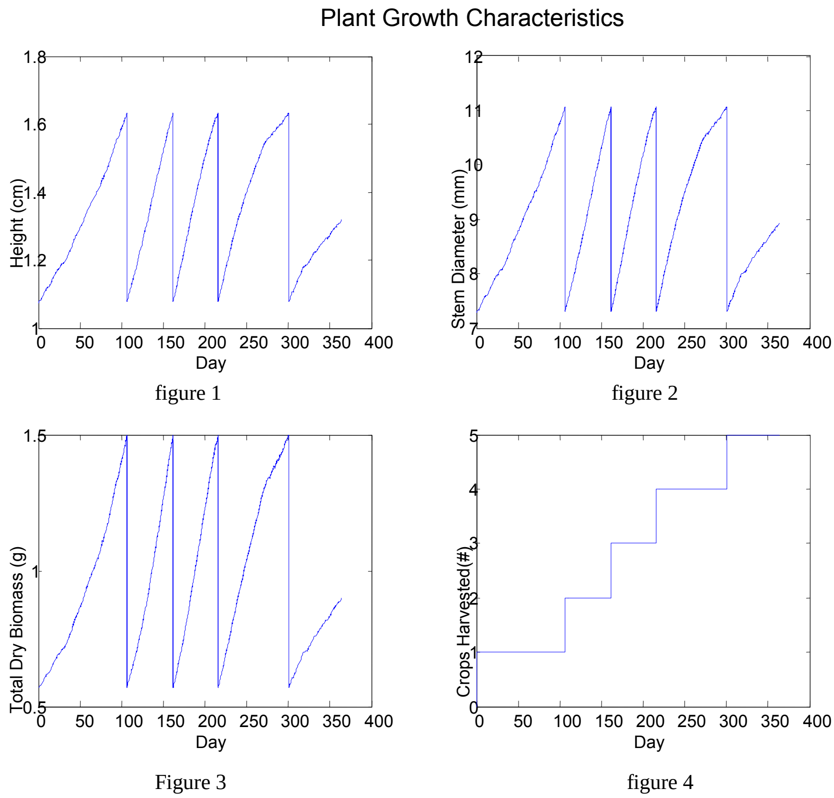


Fig.6. Figure 1 is the height in cm, Figure 4 is the cumulative number of growing season, Figure 3 is the total biomass (dry weight), and Figure 2 is the rod diameter in mm.

The speed of growth of the mass of the plant is normal for most of the year except in the end of autumn and beginning of winter because of the temperature drops at night and we discussed this problem and its correction previously.

The figure shows the characteristics of the plant and how often the product is harvested for one year in each season, also the speed of the harvest at each period, such that it is found that by applying our blurred controller we can harvest four times In a year for the wet region of Dar El Beida, but at the end of the year to December and beginning of the year to January it is noticed that the operation of the crop or the growth of the plant is A bit heavy and take little more time than the other seasons.

This negative growth is caused by insufficient integral light during the winter and which means a break in our model and a lowering in light and photoperiod. And this indicates that despite the results obtained in the desired interval, our blurred controller found difficulties for the optimal climate management inside our model of the greenhouse and exactly in the winter period (end of December and beginning of January) and this indicates that our system is unstable in this period.

And it makes us think of its development and improve it in the future to get better results.

6. Conclusion

The main objective of this work was to explore and develop intelligent control schemes to control the greenhouse climate (ie air temperature and relative humidity). Our article also develops a control by fuzzy logic using the Mamdani method for the purpose of optimizing the micro-climate management of the agricultural greenhouse. And to know the defects that can occur in the climate controller of the greenhouse and to impair its operation.

Due to interactions between crop and greenhouse atmosphere, simultaneous control of temperature and humidity is one of the most challenging tasks.

This is due to the fact that these two variables are strongly influenced not only by temperature and humidity on the outside, but also by the radiation and the physiological response of the culture. Because of the problems of usages of classical controllers then our work was done to improve the techniques of control of the climate inside the greenhouse.

Today, climate control of greenhouses is an essential concept, Climate control of greenhouses is today an essential concept. In this work, we first discussed the types of agricultural greenhouse and the parameters needed for the control of their micro climate, as well as its characteristics and plant needs, in addition to the essential components for managing climatic parameters under greenhouse conditions . Afterwards the control and control techniques applied for the micro-climate management of the greenhouse were cited.

As a result we discussed the dynamic models used in the modeling and development of our greenhouse and created a real database for the validation of our model. And we discussed on the basis of the controller by the fuzzy logic considering the internal parameters as well as external parameters.

The advantage of this controller is that we considered external perturbations. But due to the slow process for a few hours during the day, the model was valid throughout the year except in (December -January) where there was a break in our model which indicates that our system is unstable during this time.

To reduce the limitations of this controller in the future we can extend the project of two separate fuzzy controllers that can design by considering the rate of change in the input so that the system will become more stable.

However, our objectives are achieved insofar as we have been able to show through modeling and control by the use of fuzzy logic, this domain is very difficult because it is multi-variable control and the greenhouse constitutes A biophysical system, where the parameters are strongly correlated as the results show. This technique of fuzzy logic has been adapted to the greenhouse to a promising future for the control and climatic management of the greenhouse. For locksmiths, it is a privileged approach to the structuring and aggregation of knowledge and also a means of identifying gaps in the understanding of mechanisms and interactions that occur in the greenhouse system.

Fuzzy logic is a branch of artificial intelligence, the advantages and disadvantages of which must be pointed out. Its use has led to rather satisfactory results in terms of control and regulation.

We remain optimistic in the near future, with regard to the exploitation of artificial intelligence, and in particular the use of fuzzy logic which points out:

Control and regulation of the greenhouse microclimate.

- By conserving energy.
- Efficient use of energy in greenhouse operations.
- Better productivity of greenhouse crops. .
- A significant reduction in human intervention.

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