



COMPARISON OF MODELING AND SIMULATION RESULTS MANAGEMENT MICRO CLIMATE OF THE GREENHOUSE BY FUZZY LOGIC BETWEEN A WETLAND AND ARID REGION

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Abstract:

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. In this paper we present comparison of modeling and simulation management of the greenhouse microclimate by fuzzy logic between a wetland (Dar El Beida Algeria) and the other arid (Biskra Algeria).

Key Words: Modeling, Fuzzy Logic Controller, Optimization, Simulation, Greenhouse & Microclimate

1. Introduction:

Agricultural greenhouse originally designed as a simple enclosure limited by a transparent wall, as is the case for conventional tunnel greenhouses and largely answered chapel in several countries including those of the Mediterranean basin. They amplify certain characteristics of the surrounding environment, thus involving variations of internal energy and fairly significant heat loss due to the low inertia (Bendimerad *et al.*, 2014) of the clamp system. 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 (Bibi-Triki *et al.*, 2011) (ground, culture, cover, indoor and outdoor environment). To develop non-stationary mathematical models usable for simulation, optimization (Faouzi Didi *et al.*, 2016) 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 (El Aoud and Maher, 2014) 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 (Abdelhafid Hasni *et al.*, 2008) harvest.

Many facilities have been designed to regulate and monitor climate variables in an agricultural greenhouse (Draoui *et al.*, 2013), such as: Temperature, Humidity, CO₂ concentration, Irrigation, the ventilation (Hasni *et al.*, 2009), etc. The possibilities offered by greenhouse climate computers have solved the problems relating to the regulation and respect of climate instructions required by protected cultivation.

In this paper, or using fuzzy logic (Bouaama *et al.*, 2008 and Dhamakale and Patil, 2011), 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.

2. Equation of State:

2.1 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 .

$$\begin{aligned}
 \overbrace{\rho_{\text{air}} V_{\text{GH}} C_{p,\text{GH}} \frac{dT_{\text{in}}}{dt}}^{\text{STORAGE}} &= \overbrace{\alpha_{\text{SW}} \tau_{\text{glass}} I}_{\substack{\text{Shortwave} \\ \text{Solar} \\ \text{GAIN}}} + \overbrace{Q_{\text{heaters}} + \dots}_{\text{GAIN}} \\
 &\quad - \overbrace{\frac{r_{\text{conv},\text{out}} + r_{\text{cond},\text{cover}}}{r_{\text{conv},\text{in}} + r_{\text{cond},\text{cover}} + r_{\text{conv},\text{out}}} \lambda K_{\text{cond}} A_{\text{cover}} [VP_{\text{in}} - VP_{\text{sat}}(T_{\text{cover}})]}_{\substack{\text{Condensation} \\ \text{LOSSES}}} \dots - \\
 &\quad \underbrace{h_{r,\text{sky}} (1 - \epsilon_{\text{cover}})(T_{\text{in}} - T_{\text{sky}}) - 0.8 \epsilon_{\text{cover}} h_{r,\text{cover}} (T_{\text{in}} - T_{\text{cover}})}_{\substack{\text{longwave} \\ \text{LOSSES}}} \dots - \\
 &\quad \underbrace{A_{\text{floor}} \eta_{\text{utilization}} \frac{\Delta R_{\text{net}}}{\Delta + \gamma}}_{\substack{\text{Evapotranspiration} \\ \text{LOSSES CONT}}} \dots - \\
 &\quad \underbrace{\left[\frac{1}{r_{\text{conv},\text{in}} + r_{\text{cond},\text{cover}} + r_{\text{conv},\text{out}}} A_{\text{cover}} + P_{\text{floor}} (U\ell)_{\text{perimeter}} \right] (T_{\text{in}} - T_{\text{out}})}_{\substack{\text{conduction} \\ \text{LOSSES CON}}} \dots \\
 &\quad - \underbrace{\lambda K A_{\text{net}} (VP_{\text{sat}}(T_{\text{wb}} [T_{\text{air}}, rh_{\text{air}}]) - VP_{\text{air}})}_{\text{Foggers}}
 \end{aligned} \tag{1}$$

$r_{\text{conv},\text{in}}, r_{\text{conv},\text{out}}$: Heat transfer coefficient inside and outside by convection (W/m².k).

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).

2.2 The Mass Transfer in the Greenhouse:

The mass balance for moisture in the greenhouse can be written as following eq (2):

$$\rho_{air} V_{greenhouse} \frac{de_{in}}{dt} = -\dot{V}_{inf} * \rho_{air} (H_{in} - H_{out}) - \dot{V}_{vent} * \rho_{air} (H_{in} - H_{pad}) +$$

$$\underbrace{\frac{1}{\lambda} A_{floor} \eta_{utilization} \frac{\Delta R_{net}}{\Delta + \gamma}}_{\text{Evapotranspiration}} - \underbrace{K_{cond} A_{cover} [VP_{in} - VP_{sat}(T_{cover})]}_{\text{condensation}} +$$

$$\underbrace{KA_{net} (VP_{sat}(T_{wb}[T_{air}, rh_{air}]) - VP_{air})}_{\text{foggers}} + \underbrace{r\phi e_{sat}(T_{exhaust}) \frac{Q_{heat}}{h_{combustion}}}_{\text{combustion}}$$

$\dot{V}_{inf}$: The speed of air infiltration (m/s).

$V_{greenhouse}$: The total volume of agricultural greenhouse (m³).

H_{in}, H_{out} : Is the indoor and outdoor humidity (KJ / kg).

$\dot{V}_{vent}$: Ventilation rate (m³ 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 eq (3):

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

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

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" (Gurbaoui et al., 2013). 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

(https://en.wikipedia.org/wiki/Fuzzy_control_system).

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 (Dhamakale and Patil, 2011;

https://en.wikipedia.org/wiki/Fuzzy_control_syste).

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 Fuzzification 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:

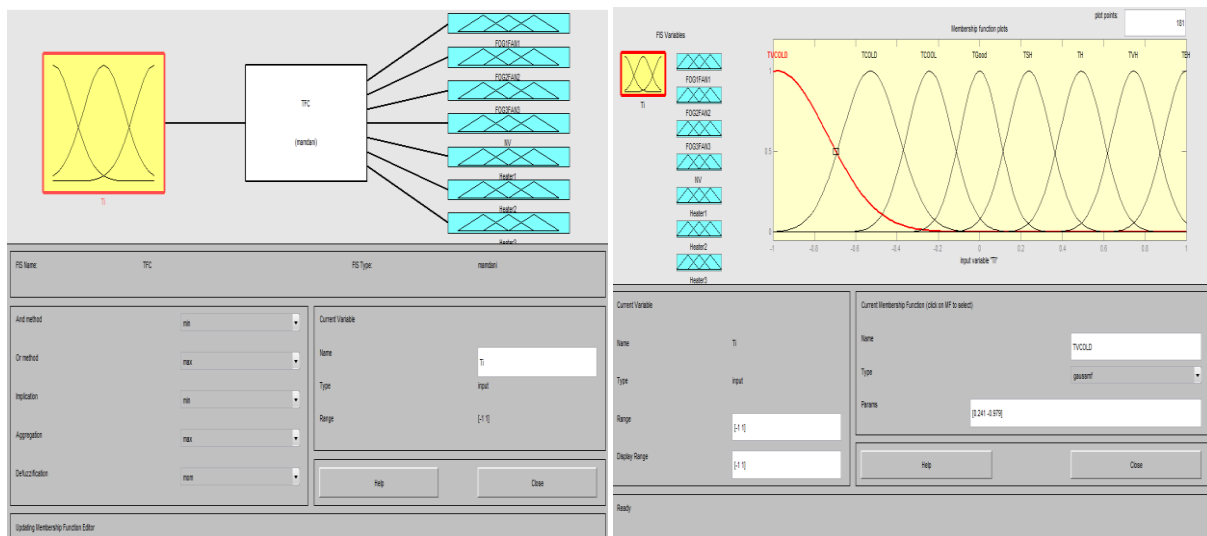


Figure 1: Representation rules of membership

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 TCOOL) 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 / m².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 and Biskra 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.

4.1 Greenhouse Climate Model:

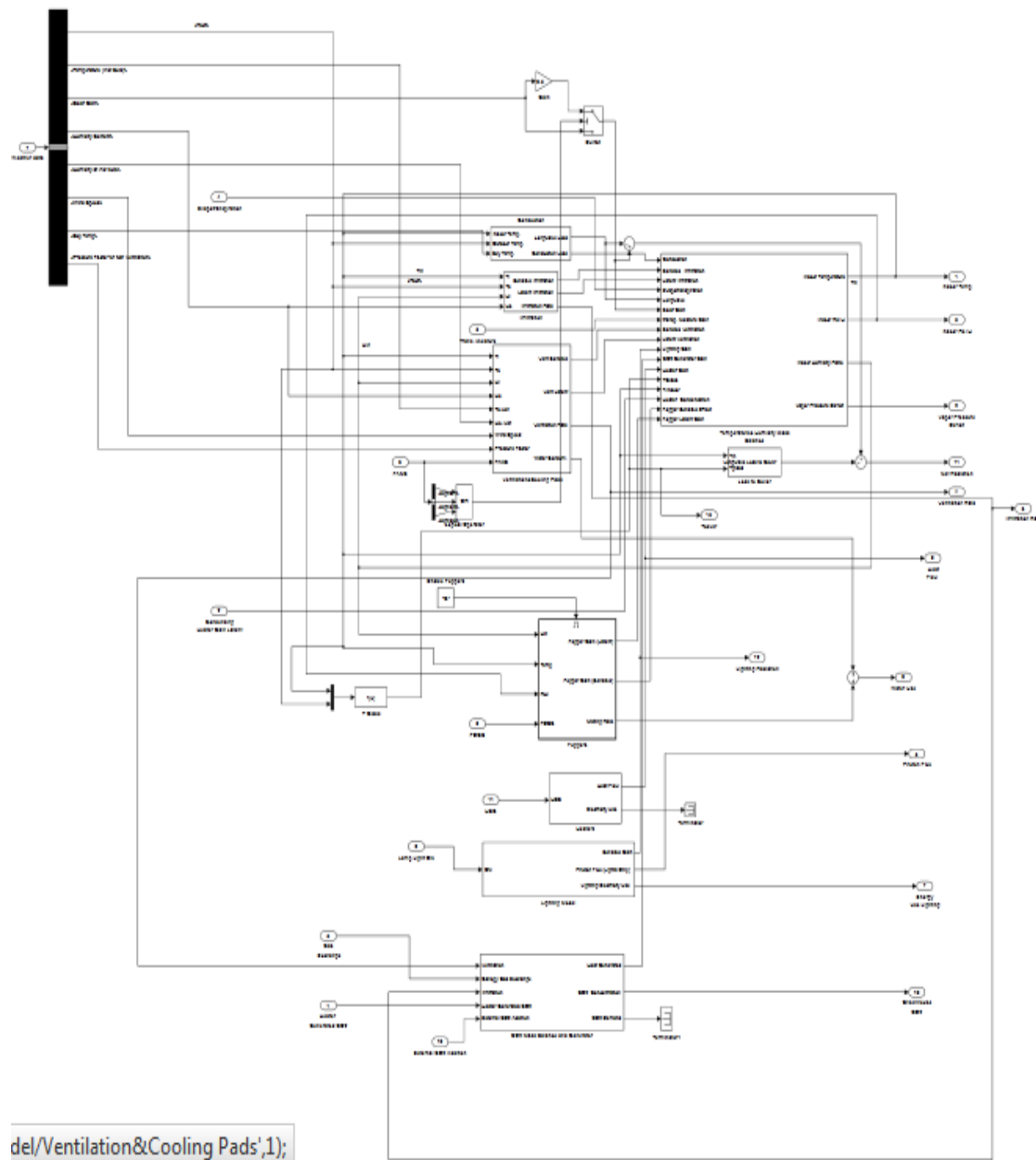


Figure 2: SIMULINK Representation of the Greenhouse Climate Model

4.2 Fuzzy Logic Controller Simulation Model of the Greenhouse:

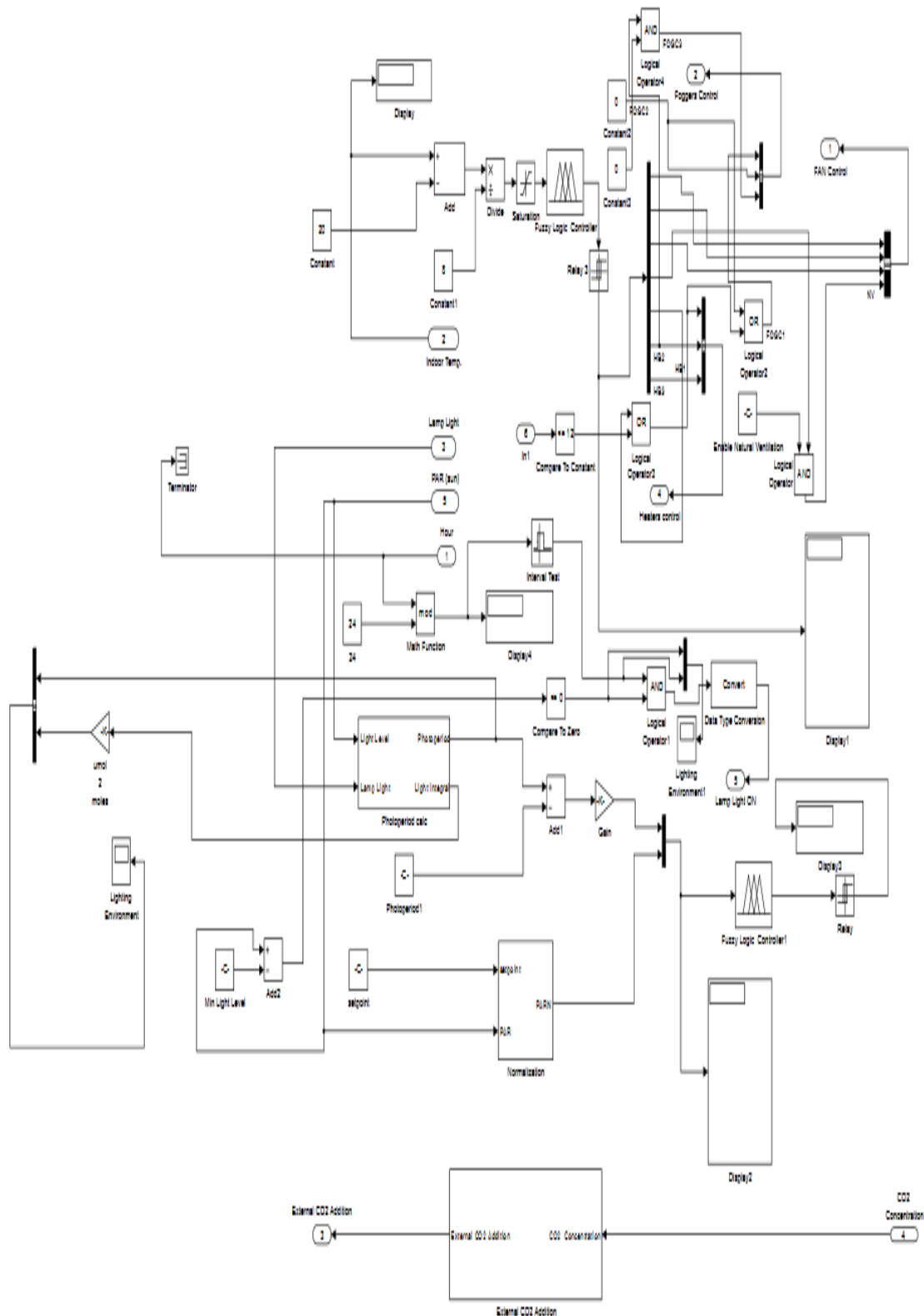


Figure 3: SIMULINK Representation of the Fuzzy Logic Controller Model Discussions on above Figures (2-3):

While a complete list of equations may show the relationships between quantities, it provides no indication of how these equations are to be solved numerically on the computer, let alone how they are to be expressed and organized as part of the

overall model software. Esoteric mathematical equations must be translated into computer code, which upon compilation and execution translates raw input data into meaningful output. Nothing is said about the different pre and post processing steps which must taken to go from raw input data to meaningful output graphs.

In a block diagram, each machine or block is described by three sets of variables: The inputs, the state variables which describe the condition of the machine and the output which depend directly upon the state. At each time step, the machine or block can be called upon perform to following commands:

- ✓ Initialize/reset outputs and states
- ✓ Calculate state derivatives
- ✓ Integrate state derivatives to calculate future state
- ✓ Calculate outputs based upon current state

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 in arid and wetland region

(<http://www.wunderground.com/cgi-bin/findweather/getForecast?query²>).

✓ Results Simulation for the Wetland Region (Dar El Beida):

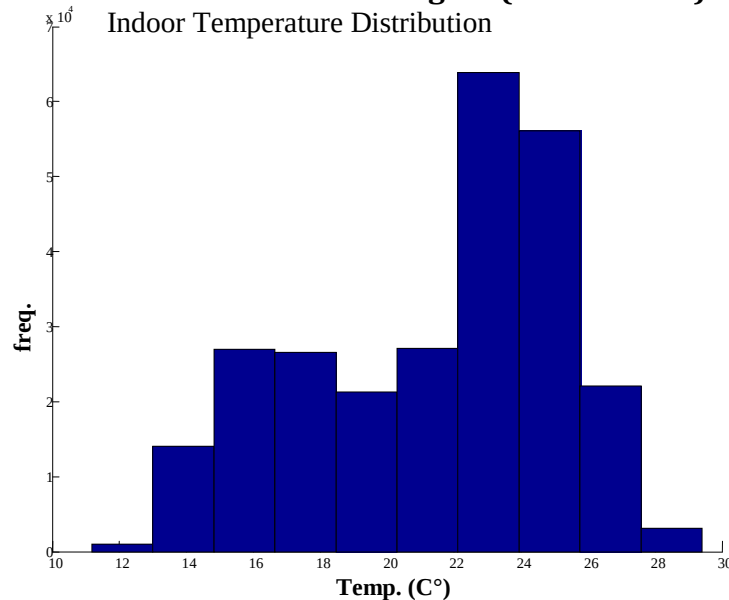


Figure 5: Histogram shows the distribution of indoor

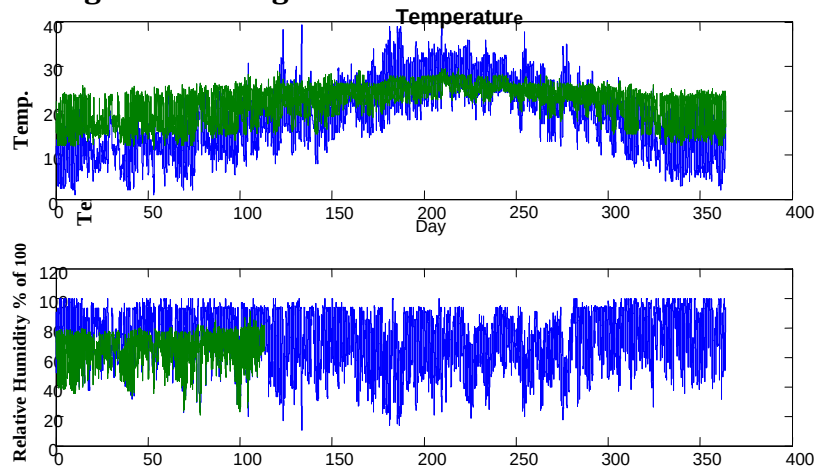


Figure 6: The evolution of Humidity and Temperature (Interior / Exterior)

✓ **Results Simulation for the Arid Region (Biskra):**

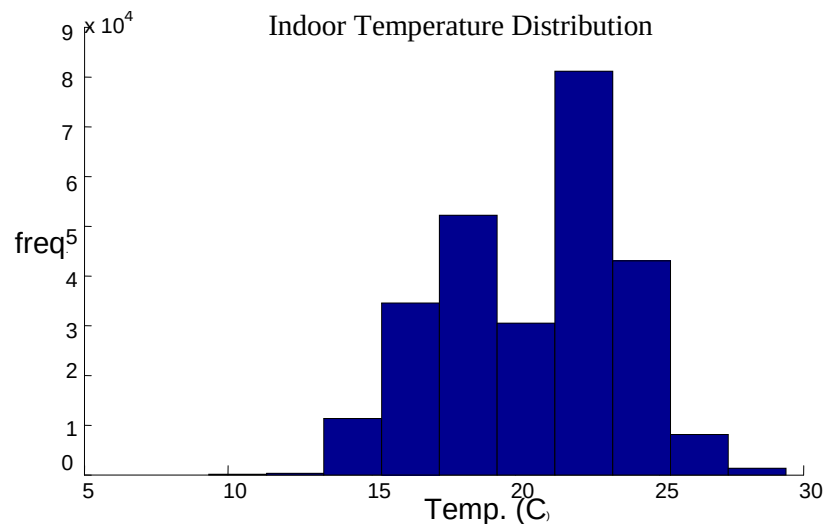


Figure 7: Histogram shows the distribution of indoor

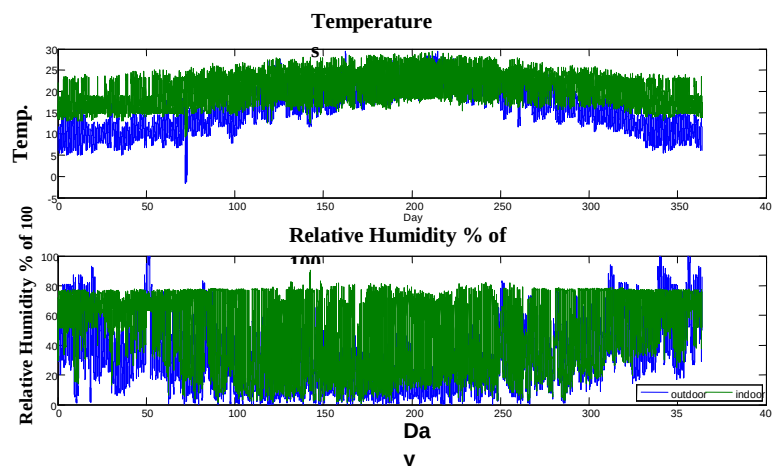


Figure 8: The Evolution of Humidity and Temperature (Interior / Exterior)

✓ **Discussions on above Figures (5, 6, 7, 8):**

It is found in the wetland region (Dar El Beida) 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. But Conversely in the arid region It is found that most of the internal temperature values are in the range 15 °C to 25 °C for the autumn winter period, and in the range 20 °C to 28 °C for the spring summer period in a large variation the temperature during the winter autumn period is due to heat loss during

the night, clearing heating is insufficient and expensive for this improved thermal insulation of the covering wall is necessary.

The improved thermal insulation of the cover may be carried out in practice by the addition of an plastic air bubble layer mounted to the inside wall face.

During the period spring summer the temperature is almost within the desired range except for half of the summer where the temperature is a little increase.

The use of cooling systems and spray is necessary to lower the temperature in the interval longed for.

But this solution is insufficient and really expensive, for this purpose we should improve the characteristics of the coverage of the agricultural greenhouse for example thermal insulation or blanket double wall which demonstrates improved efficiency of heating and cooling ... etc

The relative humidity generally stays close to the optimum for all the year except in summer when the humidity drops below threshold due to significant vaporization used for temperature compensation, to resolve this problem adding a screen on the roof of the greenhouse and improving irrigation can compensate the lack of relative humidity in the arid region.

6. Conclusion:

However, our objective is achieved to the extent that it has been shown through modeling and control by the use of fuzzy logic, this area is very difficult because it is a multi control variables which the greenhouse is a biophysical system where parameters are highly correlated as shown by the results. This technique of fuzzy logic that has been adapted to the greenhouse to a promising future for the climate control and management of the greenhouse. For greenhouse growers, it is a preferred approach for structuring and knowledge aggregation and as a means of identification of gaps in the understanding of mechanisms and interactions that occur in the system - greenhouse.

Fuzzy logic is a branch of artificial intelligence, which must point out its advantages and disadvantages. Its use has led to quite satisfactory results of the control and regulation perspective.

We remain optimistic in the near future, as to the operation of artificial intelligence, including the use of fuzzy logic which indicates:

- ✓ For the control and regulation of the greenhouse microclimate.
- ✓ By the conservation of energy.
- ✓ For the efficiency of energy use in the greenhouses operation.
- ✓ For improved productivity of crops under greenhouses.
- ✓ In a significant reduction of human intervention.

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