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Adaptive Non Linear PID Controller for Green House Climate Control

*Shubham Gupta, **Dr. Sulochana Wadhwani
*Dept. of Electrical Engg.
Madhav institute of Technology and science Gwalior, India
shubhamgupta.konch@gmail.com
**Dept. of Electrical Engg.
Madhav Institute of Technology and Science Gwalior,India
sulochana_wadhwani1@rediffmail.com

ABSTRACT
This paper presents the novel control strategy, for green house climate control. Till now, there are many control strategy that is work in India, to control green house environment but they are not adequate for good control performance. The controller used in the present work is conventional proportional, integral and derivative (PID) controllers with adaptive neural network. It provides good adaptability, strong robustness and real time performance for complex satisfactory control performance for the complex and nonlinear greenhouse climate system.

Keywords: Nonlinear system, adaptive control system, PID controller, Evolutionary algorithms.

I. INTRODUCTION

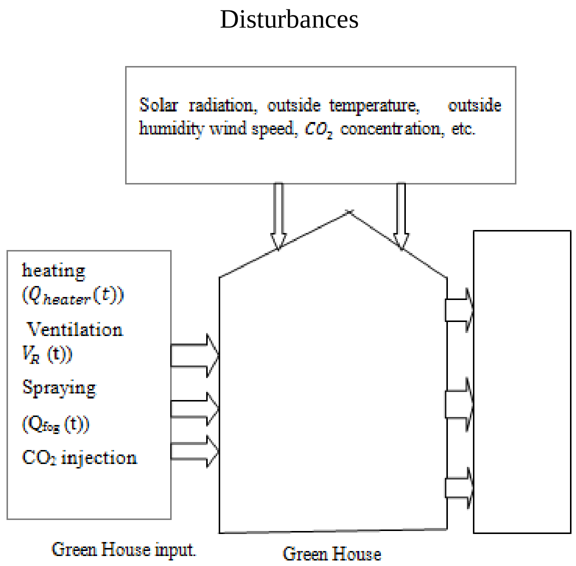
India's economy is highly influenced by the agriculture production. For the economic prosperity we have a good agriculture production. If India has to emerge as an economic power in the world, our agricultural prosperity should equal to those countries, which are currently rated as economic power of the world. We need a new and effective technology which can improve continuously the productivity, profitability, sustainability of our major forming systems. One such technology is the green house technology. Although it is centuries old, it is new in India,

About 95% of plants, either food crops or cash crops are grown in open field. In some of the temperate regions where the climate conditions are extremely adverse and no crop can be grown, man has developed methods of growing some high value crop continuously by providing protection from excessive cold, which is called as Green house technology. So, green house technology is technology is the technique of providing favorable environment condition to the plants. It rather is used to protect the plants from adverse climate conditions such as wind, cold, excessive radiations, insects and diseases. It is also of vital importance to create an ideal micro climate around the plants. This is possible by erecting a green house/glass house, where environmental conditions are so modified that one can grow any plant in any place at any time by providing suitable environmental conditions with minimum labor.

II. GREEN HOUSE DYNAMIC MODEL

The green house effect refers to the circumstances where the short wavelengths of visible light from the sun pass through the transparent medium and absorbed, but the longer wavelengths of infrared re- radiation from the heated objects are unable to pass through that medium. The trapping of the long wavelength radiation leads to more heating and higher resultant temperature.

To know the dynamic behavior of a green house system, we construct a dynamic model that is complex dynamic system. To explain the green house dynamic model many methods have been proposed, but out of these, two different approaches describe the green house climate: one is based on energy and mass flow equations describing the process, and another is based on the analysis of input output data from the process by using a system identification approach.



This paper uses the first method for the control of inside air temperature and humidity of a green house, and its physical model describes flow and mass transfers, generated by the differences in energy and mass content between inside and outside air, by control, or by exogenous energy and mass inputs. Most analytic models on analysis and control of the green house environment based on the following state space form:

$$\dot{x} = f\,(t, x, u, v) \qquad (1)$$

To simplify the model, we consider only primary disturbance variables, such as solar radiation, outside temp. and humidity. According to the above analysis, the state equations have been formed based on the laws of conservation of enthalpy and matter, and the dynamic behavior of states is described by using the differential equations.

$$\frac{dT_{in}(t)}{dt} = \frac{1}{\rho c_{p} V_T}(Q_{heater}(t) + S_i(t) - \lambda Q_{fog}(t)) - \left(\frac{V_{R(t)}}{V_T} + \frac{UA}{\rho C_p V_T}\right)(T_{in}(t) - T_{out}(t)) \qquad (2)$$

$$\frac{dH_{in}(t)}{dt} = \frac{1}{\rho V_H} Q_{fog}(t) + \frac{1}{\rho V_H}(E(S_i(t), H_{in}(t))) - \frac{V_R(t)}{\rho V_H}(H_{in}(t) - H_{out}(t)) \qquad (3)$$

Where

- T_{in}/T_{out} is the indoor/outdoor air temperature(in degree Celsius).
- H_{in}/H_{out} is the interior/exterior humidity ratio (g[H_2O]k_g^{-1} [dry air]),
- UA is the heat transfer coefficient of enclosure (WK^{-1}),
- V is the geometric volume of the greenhouse (m^3),
- ρ is the air density (k_g [air] m^{-3}),
- C_p is the specific heat of air (J$k_g^{-1}k^{-1}$),
- Q_{heater} is the heat provided by the greenhouse heater(W),
- Q_{fog} is the water capacity of the fog system (g[H_2O]s^{-1}),
- S_i is the intercepted solar radiation energy (W),
- λ is the latent heat of vaporization (Jg^{-1}),
- V_R is the ventilation rate (m^3[air]s^{-1}),
- E(S_i(t), $H_{in}(t)$) is the evapotranspiration rate of plants(g[H_2O]s^{-1}),

V_T and V_H are the active mixing air volumes of the temperature and humidity respectively Generally speaking, V_T and V_H are as small as 60%-70% of the geometric volume V of the greenhouse owing to local convection and stagnant zones that exist in ventilated spaces.
It is also worth noting that as a first approximation, the evapo-transpiration rate

$$E\,(S_i, H_{in}) = \alpha\frac{S_i(t)}{\lambda} - \beta_T H_{in}(t) \qquad (4)$$

where α is an overall coefficient to account for shading and leaf area index(dimensionless) and is the overall coefficient to account for thermodynamic constants and other factor evapotranspiration.

III. PROBLEM FORMULATION

The climate model provided above can be used in all seasons, and two variables are controlled, namely, the indoor air temperature and the humidity ratio through the processes of heating $(Q_{heater}(t))$, ventilation and fogging $(Q_{fog}(t))$. For summer operation in this work Q_{heater} is set to zero. The purposes of ventilation are to exhaust moist air and to replace it with outside fresh air, to control high temperatures caused by the influx of solar radiation, to dehumidify the greenhouse air when the humidity of the outside air is very low, to provide uniform air flow throughout the entire greenhouse, and to maintain acceptable levels of gas concentration in the greenhouse. Fogging systems (such as misters, fog units, or roof sprinklers) are primarily used for humidification of the greenhouse. In fact, fogging system also plays a cooling role due to evaporative cooling. Moreover, fresh air must be continually ventilated into the greenhouse, while warm and humidified air is exhausted. When humidification occurs under sunny conditions, ventilation is necessary since the greenhouse would soon become a steam bath if fresh dry air is not provided.

In order to effectively express the state-space form, we define the inside temperature and absolute humidity as the dynamic state variables, $x_1(t)$ and $x_2(t)$, respectively, the ventilation rate and the water capacity of the fog system as the control (actuator) variables, $u_1(t)$ and $u_2(t)$, respectively, and the intercepted solar radiant energy, the outside temperature, and the outside absolute humidity as the disturbances, , i =1,2,3. Equations (2) and (3) can alternatively be written in the following state-space form:

$$\dot{x}_1(t) = \frac{UA}{\rho c_p V_T} x_1(t) - \frac{1}{V_T} x_1(t)\, u_1(t) - \frac{\lambda}{\rho c_p V_T} u_2(t) + \frac{1}{\rho c_p V_T} v_1(t) + \frac{UA}{\rho c_p V_T} v_2(t) + \frac{1}{V_T} u_1(t) v_2(t) \quad (5)$$

$$\dot{x}_2(t) = \frac{\beta_T}{\rho V_H} x_2(t) + \frac{1}{\rho V_H} u_2(t) + \frac{\alpha}{\lambda_0 V_H} v_1(t) - \frac{1}{\rho V_H} x_2(t)\, u_1(t) + \frac{1}{\rho V_H} u_1(t)\, v_3(t) \quad (6)$$

Due to the complexity appearing as the cross-product terms between control and disturbance variables, Equations (5) and (6) are obviously coupled nonlinear equations, which cannot be placed into the more familiar form of an affine analytic nonlinear system.

IV. CONTROL STRATEGY

To understand the control strategy, I begin it from the system input and output, after that we apply feedback control strategy to improve performance with PID controller and to judge the control system performance and get the satisfactory results we apply evolutionary algorithm and RBF networks then we combine both parameter controller because one parameter effect the other. So to simulate its behavior on MATLAB we use square wave input rather than step input to get the desire results. The proposed control strategy is taken from the various references that are available on the controlling of green house climate. In figure 4.1 green house system shown as an open loop system.

Where

Input are u_1 and u_2 which is ventilation provided by exhaust fan, and its speed controlled by PID controller and as a simple system.

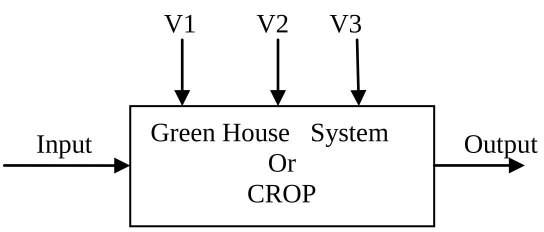


Figure4.1. Green House system as an open loop system.

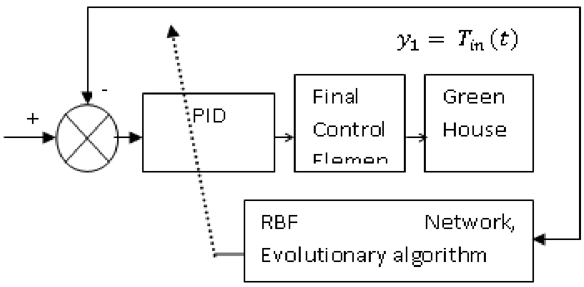


Figure 4.2 Controlling of Temperature In Green House in Adaptive manner

Here final control element is the exhaust fan and its speed Provide outside fresh air and this outside fresh air by the evaporative coaling reduces the inside temperature of green house. Similarly misting unit opening of water outlet valve provide the required amount of fogging. One final control element mechanism effect the other parameter, by this way it become a coupled nonlinear system.

V. RESULTS

The proposed technique is applied on the following greenhouse model: greenhouse surface area:1000 m^2, height: 4m. the green house has a shading screen that reduces the incident solar radiation energy by 60%. The maximum water capacity of the fog system is 26 $g[H_2O]min^{-1}m^{-3}$.Maximum ventilation rate corresponds to 20 air changes per hour(22.2 m^3s^{-1}). The parameters of the green house climate model are shown in table 1. The initial values of indoor air temperature and humidity ratio are 25^0C and 20 $g[H_2O]/kg[air]$,respectively. Here, the threshold ϒ = 0.0085,the lag number $n_1 = n_2 = 2$, and the sampling time is 1 min.

Table 1. Greenhouse model parameters

Parameter name	Unit expression	values
UA = Heat transfer coefficient of enclosure	kWK^{-1}	25
α = overall coefficient to account for shading and leaf area index (dimensionless)		0.12952 4267
β_T = overall coefficient to account for thermodynamic constants and other factors affecting evapotranspiration.	$Kgmin^{-1}m^{-2}$	0.015
V_T = active mixing air volumes of the temperature.	m^3	0.65V
V_H= active mixing air volumes of the humidity	m^3	0.65V
λ = latent heat of vaporization	Jg^{-1}	2,257
P = air density	$Kg[air]m^{-3}$	1.2
C_p= specific heat of the air	$Jkg^{-1}K^{-1}$	1,006

The performance of proposed control strategy and conventional PID controller as shown in Table 2.

Table2 . Performance comparison between RBF on line tuning and conventional PID controller.

Methods	Temperature Error (^oC)		Humidity Error ($g[H_2O]min^{-1}m^{-3}$]	
	Mean	STD	Mean	STD
RBF Online Tuning	-0.9123	2.8812	0.3660	1.3550
Convention PID Tuning	-1.9123	5.8812	0.9960	1.8750

It can be seen that the proposed scheme for controlling the parameters of the green house model is much more better than that of conventional PID controller.

VI. CONCLUSIONS

This technique is not to be limited only for green house system but it is useful for the same type of other multi input and multi output complex coupled non linear application. Therefore further improvement and implementation of the system will be achieved in near future.

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