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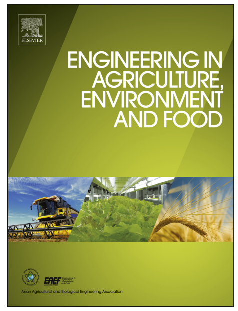

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Research Article

Towards Discrete Time Model for Greenhouse Climate Control

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Abstract: This paper presents a discrete-time greenhouse climate model to meet the requirement of model-based greenhouse climate discrete control. In this model, three state variables including the indoor temperature, humidity and CO_2 concentration and several control actions are considered. To save several states, algebraic fitting technique and time sequence functions are used to estimate some variables such as the temperatures of cover, canopy and floor. To improve simulation performance of the discrete-time model, polynomial is employed to approximate some unmodeled dynamics, and least square technique and Levenberg-Marquardt (LM) algorithm are used to identify the parameters of relevant terms in the model. The model is validated by a complete greenhouse climate model and a Venlo type commercial greenhouse, and the results indicate that the proposed model demonstrates good simulation performance, and is suitable to be used to greenhouse climate control design.

Keywords: Greenhouse climate control, discrete-time modeling, polynomial approximation, Levenberg-Marquardt algorithm.

Nomenclature

T_{air}	Inside air temperature of greenhouse (^oC)	M_{H_2O}	Molar mass of water (kg/kmol)
H_{air}	Inside humidity of greenhouse (g/m^3)	k_{air_cov}	Heat transfer coefficient between inside air and cover (W/(m^2.K)
$CO_{2,air}$	Inside CO_2 concentration of greenhouse (mg/m^3)	k_{flr_air}	Heat transfer coefficient between floor and inside air
P_g	Photosynthesis rate of crop canopy (mg/(s·m^2)	α_{leaf_air}	Convective heat exchange coefficient from the canopy leaf to the greenhouse air(W/(m^2.K))
E	Transpiration rate of crop canopy (kg/s.m^2)	$c_{leakage}$	Greenhouse leakage coefficient
R_e	Respiration rate of crop canopy (mg/(s·m^2)	η_{mg_ppm}	CO_2 conversion factor from mg/m^3 to ppm
LAI	Leaf area index of crop	α_{can}	Solar radiation absorption coefficient
SLA	Specific leaf area of crop	τ_{can}	Transmission coefficient of canopy
DM	Dry matter of crop (mg/m^2)	γ	Psychrometric constant
DM_{fruit}	Dry matter of fruit (mg/m^2)	g	Acceleration of gravity (m/s^2)
DM_{stem}	Dry matters of crop stem(mg/m^2)	C_d	Ventilation discharge coefficient that depends on greenhouse shape
r_b	Boundary layer resistance of the canopy for vapor transport	C_w	Ventilation global wind pressure coefficient that depends on greenhouse shape
r_s	canopy resistance for transpiration	k_d	Heat transfer coefficient between floor and soil
T_{out}	Outside air temperature (^oC)	Cap_{flr}	Heat capacity of floor
H_{out}	Outside humidity (g/m^3)	α_{flr}	Absorption coefficient and
$CO_{2,out}$	Outside CO_2 concentration (mg/m^3)	ρ_{flr}	Reflection coefficient of floor
I_{sun}	Solar radiation above shade net (W/m^2)	Φ_{heat}	Capacities of heating system(W)
I_{glob}	Solar radiation above cover(W/m^2)	$\Phi_{CO_{2,air}}$	Capacities of CO_2 supply system (mg/s)
R_{can}	Solar radiation above canopy	Φ_{fog}	Capacities of fogging system (g/s)
PAR	Photosynthesis active radiation absorbed by canopy	Q_{can_air}	Heat flux between the inside air and canopy(W/m^2)
V_{wind}	Outside wind speed (m/s)	Q_{flr_air}	Heat flux between the inside air(W/m^2)
u_{heat}	Heating input variable	Q_{air_cov}	Heat flux between the inside air and cover(W/m^2)
u_{fog}	Fogging input variable	Q_{vent}	Heat flux between indoor and outdoor due to ventilation(W/m^2)
u_{CO2}	CO_2 injecting input variable	Q_{heat}	Heat flux from heating system(W/m^2)