Use of MatLab environment for development of automatic control systems of temperature and humidity regime in a greenhouse using neural regulators

I N Morozov
Federal State Budgetary Educational Institution of Higher Education "Murmansk Arctic State University", Murmansk, Russia
E-mail: moroz.84@mail.ru

Abstract. In this work, a two-level system for automatic control of temperature and humidity conditions in a greenhouse was synthesized. To maintain controlled parameters, it was proposed to use a neuroregulator in the system. The study of the developed control system was carried out using the MatLab software environment, the Simulink application. A qualitative assessment of the results of modeling the operation of the system in various modes was made, which showed the viability of using these systems in greenhouse enterprises.

1. Introduction
Recently, great attention has been paid to the quality maintenance of the microclimate in greenhouse enterprises. To increase the yield, it is necessary to choose the right technology for maintaining the microclimate [1-9]. It should be noted that the use of energy efficient devices and technologies can further reduce the cost of manufactured products. Automated control systems at such enterprises should make the most efficient use of the hardware component of executive systems and maintain the specified operating modes within the framework of the technological regulations.

Now, modernization of greenhouse equipment and control systems is being carried out everywhere. The modernization affects many elements: the modernization of the vents, the installation of curtain systems, the separation of circuits, the installation of fans. With an increase in the number of actuators of microclimate control systems, the requirements for the automatic control systems themselves also increase. An increasing number of control criteria are emerging (for example, saving heat resources, maintaining humidity, maintaining temperature conditions at different levels, etc.).

The experience of the formation of new complex automatic control systems that respond to dynamically changing deviations from the given parameters shows that when choosing a control criterion, it is not sufficient to take into account only one specific parameter. The task of modern systems is reduced to the formation of control decisions for a certain set of parameters, the dependence of which on each other is often not known. Revealing the dependencies poses a rather difficult task for the developers, but at the same time provides the agronomist-technologist with many opportunities in choosing a method for maintaining the temperature and humidity regime in the greenhouse.

To solve this kind of problems, it is possible to use neural network technologies in control systems [10]. This method of neural network regulation, with sufficient tuning, will reveal the hidden dependencies between numerous controlled parameters and form management decisions that will allow the regulation process to be carried out within the specified limits.
2. Description of the automation object and the algorithm of its functioning
The functional diagram of the considered system for maintaining the temperature and humidity regime in the greenhouse is shown in figure 1. It consists of two levels. The lower level is a control subsystem. This includes sensors, actuators, process plants, and a microcontroller. The upper level will be an operator's workstation. The RS-485 interface provides level communication.

![Figure 1. Functional diagram of the considered system for maintaining the temperature and humidity regime in the greenhouse.](image)

The entire greenhouse economy consists of the following technological objects:

- Power supplies for monitoring and control systems;
- Sensors of temperature, humidity, consumption;
- Operator control panel;
- Filter;
- Pump;
- Controlling controller.

3. Object characteristics
For cultivation in greenhouse conditions of various agricultural products, as a rule, two parameters are selected as control criteria: temperature and humidity in the greenhouse; soil temperature and moisture (figure 2).

The transfer function of the control object is as follows:

\[
\frac{U(s)}{R(s)} = \frac{K}{s^2 + 2\zeta\omega_n s + \omega_n^2}
\]
Where:

\[ W(p) = \frac{K_0}{T_{oy}p + 1} e^{-\rho c} = \frac{60}{800p + 1} e^{-20p} \]  

\[ K_0 = K_{oy} \cdot K_{IM} \cdot K_d \]  

\[ Y_1(t) \] – signal from the sensor for the controlled variable;  
\[ Y_2(t) \] – signal from the sensor via the control channel.

The regulator of the considered system for maintaining the temperature and humidity regime in the greenhouse must implement a proportional-integral control law.

4. Modeling an automatic control system in MatLab

We will simulate the system of automatic regulation of temperature and humidity conditions in the greenhouse in MatLab 7.9.0 environment using the Simulink application (figure 3).

The NARMA-L2 Controller was chosen as a neuroregulator in this environment, which makes it quite easy to adjust its neural network structure and training (figure 4 and 5).

The obtained transient processes were used to determine the quality indicators of the regulation system:

- Average overshoot in reference action was ± 2.3%;
- There was no static regulation error;
The stabilization time of temperature and humidity was 3 minutes.

Figure 4. Window for setting the structure of the neural network.

Figure 5. Results of training neural network

All modeling was done for greenhouses with an area of 200 m², the cultivated crop is cucumbers.

5. Conclusion
In this work, a two-level system for automatic regulation of temperature and humidity conditions in a greenhouse was synthesized, which performs discrete regulation of air humidity and control of water consumption for spraying in a greenhouse. To maintain the controlled parameters, it was proposed to
use neuroregulation, which made it possible to take into account the hidden dependencies between these parameters and to carry out regulation within the specified boundaries of the technological regulations. The results of modeling the operation of the system in various modes have shown the viability of using these systems at greenhouse enterprises. In the course of work on the study of the response of such systems to disturbing influences, it was revealed that the system for regulating the temperature and humidity regime in the greenhouse responded adequately in all boundary conditions.

References

[1] Zakhozhiy I G, Dymova O V, Tabalenkova G N, Golovko T K and Malyshev R V 2017 regulation of the metabolism of greenhouse plants of leaf salad (lactuca sativa l.) by the effect of uv radiation. News of the Timiryazev Agricultural Academy 6 42-55
[2] Selivanova M V, Proskurnikov Yu P, Lobankova O Yu and Esaulko A N 2011 Regulation of cucumber food in conditions of protected soil. Bulletin of the agro-industrial complex of Stavropol 4(4) 14-17
[3] Gupta M J and Chandra P 2002 Effect of greenhouse design parameters on conservation of energy for greenhouse environmental control. Energy 27(8) 777-794
[4] Condori M and Saravia L 1998 The performance of forced convection greenhouse driers Renewable Energy 13(4) 453-469
[5] Bascetincelik A, Ozturk H H, Paksoy H O and Demirel Y 1999 Energetic and exergetic efficiency of latent heat storage system for greenhouse heating. Renewable Energy 16(1-4) 691-694
[6] Sharma P K, Tiwari G N and Sorayan V P S 1998 Parametric studies of a greenhouse for summer conditions. Energy 23(9) 733-740
[7] Higuchi H, Utsunomiya N and Sakuratani T 1998 High temperature effects on cherimoya fruit set, growth and development under greenhouse conditions Scientia Horticulturae 77(1-2) 23-31
[8] Larsen R U and Persson L 1999 Modeling flower development in greenhouse chrysanthemum cultivars in relation to temperature and response group. Scientia Horticulturae 80(1-2) 73-89
[9] Tiwari G N and Sharma P K 1999 Off-season cultivation of cucumbers in a solar greenhouse. Energy 24(2) 151-156
[10] Kuznetsov N M and Morozov I N 2018 Synthesis of a fuzzy regulator of productivity of the main ventilation unit of the miner Mining information and analytical bulletin (scientific and technical journal) S48 336-345