УДК 631.362.36:57.087.3
https://doi.org/10.47533/2023.1606-146X.21

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DEVELOPMENT OF INTELLIGENT CONTROL SYSTEM OF HVAC BY USING MACHINE LEARNING

The article is devoted to the problem of regulation of heat supply and air conditioning in the room. An automated system for monitoring the dynamic characteristics of such sensors is described, which is a software and hardware complex for setting up a test bench and analyzing the parameters of sensors for dynamic temperature control and air conditioning. The main purpose of this system is automation of one room by controlling air conditioning and supporting a temperature. The system performs the functions of controlling the Google Coral USB Accelerator, configuring the ADC and determining the amplitude-frequency and phase-frequency characteristics of temperature sensors, switches, leak sensors and air conditioning based on the results of their experimental studies on the stand for monitoring the dynamic characteristics of sensors and monitoring in the SCADA Genesis64 program. The scheme of the test bench, the generalized algorithm of the system operation and the screen form of the program operation are presented. The software of the automated system for temperature control and air conditioning in the room is developed on the basis of ModBus TCP, OPC UA and SCADA programs.

***Key words**: SCADA Genesis 64, intelligent system, machine learning, neural systems, air and conditioning system.*

Introduction. The majority of current health management products are used in medical institutions and do not pay enough attention to students. This research develops a student-centered and functional autonomous health management system based on this.

Currently, the regulation of indoor temperature and air is one of the most common problems in residential complexes. In the process of creating an intelligent control system, the task was set to create a supply system in a specially separated laboratory, which is located in the smart laboratory.

An important element of the Laboratory is a software package built on the basis of the leading Software-the Internet of Things platform Genesis 64. This is the so-called "Upper" level of the system of "Smart" cities, in which processes are displayed, managed, indicators are analyzed, and predictive modeling of processes is performed.

Air conditioning is an automated process of maintaining the microclimate in the room (air temperature, humidity, air circulation rate, air purity). This is necessary for the normal functioning of a person or to ensure the conditions of safety measures at the workplace in polluted areas in the enterprise. The air conditioning system of large areas is usually carried out by complex automated control systems. An automated air conditioning system controls the indoor climate, regardless of the parameters of atmospheric conditions. The main devices are placed in an apparatus called an air conditioner. Before proceeding to the gradation of air conditioning systems, it should be noted that there is still no standard classification of

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air conditioning systems and this is indicated by the fact that the basic schemes, technical and functional parameters of the SLE are diverse, as are the rooms for which this or that system is intended. Air conditioning is achieved by providing a complex of technical and technological means, in other words, an air conditioning system. The air conditioning system consists of a complex of installations, such as an air intake, cleaning and processing equipment, heat exchangers, filters, dehumidifiers or humidifiers, air circulation systems - fans, automation systems and remote control. As a rule, such air conditioning units are assembled in one or two boxes, and in this case the values “air conditioning system” and “air conditioning” are similar.

Comparison of neural network architecture. Researches were carried out on an experimental sample of the color sorter [3], the block diagram of which is shown in Figure 1. The sequence of technological processes in the color sorter includes: SH - storage hopper; VT - vibrating tray; IPT - inclined pitched tray; VC - video cameras; RU - recognition unit; MC - microcontroller; PE - pneumatic ejectors; SA1; SA2 - respectively, amplifiers for signals of pneumatic ejectors and vibrating tray; Ifr. and IIfr. - respectively, outlet pipes for the first (alfalfa seeds) and second (seeds of quarantine and hard-separable impurities) fractions.

The experimental setup is equipped with CCD Nikon AF NIKKOR cameras (52mm) with a minimum resolution of 1800-4500 pixels. A Raspberry Pi3 processor was used as a microcontroller, and a JMGD LED-W LED lamp was used to supply lighting, providing 32lx illumination in the object recognition area. Also, the color sorter is equipped with a Vibrator110V Small modei vibrating tray, Ejector 20 Blocks pneumatic ejectors, a Trays size 306mm profile pitched tray, a 64 Holes nozzle plate blowing panel, an air filter and a valve.

The optical-electronic control unit operates on the basis of its own software product “Digital Seed Cleaning”, which makes it possible to recognize seeds of quarantine and hard-separable impurities with defects of up to 64 classes [4]. The performance of the separator was regulated by the speed of transportation on a horizontal vibrating tray, at which uniform movement of the flow of seeds was ensured in one layer. Once in the survey area, each seed is examined by cameras separately, so that a high degree of purity of the seed fraction of the main crop can be achieved with a color sorter.

$$\min_{\alpha_i \gamma_i} \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j y_i y_j K(x_i, x) - \sum_{i=1}^{N} \alpha_i \tag{1}$$

In the result of researching they get the output function which was effective in summer months.

$$f(x) = \operatorname{sgn}\left(\sum_{i \neq \vartheta} \alpha_i y_i K(x_i, x) + b \right) \tag{2}$$

The method, which is using for our researches is based on machine learning and dataset, but in this time, in papers and researchers [7] and [8], they based on their mathematical model of hybrid neural system. There was presented the data output, which collected

predicted faults in normal and negative sample of system. For example, in works [9], there was shown and made the monitoring different kinds of dataset, which was combined to econom the electricity of HVAC system, results are below:

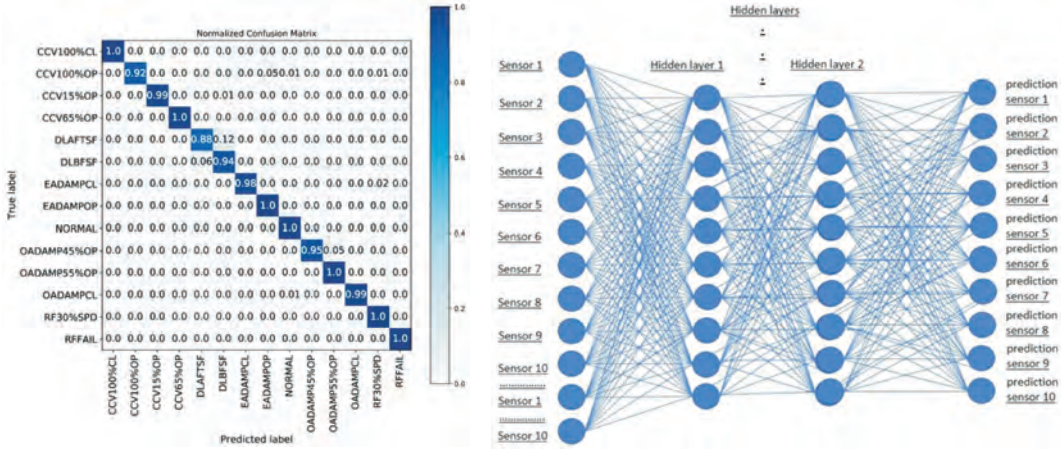


Figure 1 **–** FDD model for system

The glitch of the warming, ventilation and cooling (air conditioning) framework is viewed as a Moderna significant issue in present day structures. Because of the intricacy of the Structure The executives Framework (BMS) with the contribution of functional information from an enormous number of sensors utilized in the air conditioning framework, a breakdown can be truly challenging to recognize at a beginning phase. While various strategies for shortcoming identification and analysis (FDD) utilizing measurable and preparing models have exhibited amazing outcomes as of late, early finding stays a test, since numerous cutting edge approaches are unfeasible for diagnosing specific infringement of Moderna air conditioning and have exactness issues. In such manner, this review presents another half breed FDD approach by joining arbitrary timberland classifiers (RF) and a reference vector machine (SVM) to apply FDD to the central air framework. Exploratory outcomes show that the proposed half and half woodland irregular number machine svm (HRF-SVM) is better than different techniques with higher forecast precision (98%), in spite of the way that the indications of disappointment were moderate. Moreover, the proposed construction can essentially lessen the quantity of sensors required and function admirably with few mistaken examples of preparing information accessible in genuine applications [9].

Also to think about neural organization models, this article presents a drawn out transient memory (LSTM) model for anticipating IAT for a multi-zone building in view of direct multi-stage expectation with a consecutive methodology. Two techniques, LSTM-MISO and LSTM-MIMO, are made for a long time with one result and numerous result with different results, separately. The adequacy of these two procedures was assessed in view of two contextual analyses of truly canny structures utilizing variable wind stream (VAV) and consistent wind stream (CAV) frameworks. For the two structures, the exploratory outcomes

showed that LSTM models are better than multi-facet perceptron models, lessening the expectation mistake by 50%.[10]

Creating own neural model. The framework is a product and equipment complex for ideal control of the room's central air (Warming, ventilating and molding), gas, moistness and temperature. It comprises of a module for gathering, handling and observing room gas, stickiness and temperature information, a neural organization - based expectation module, and a choice - making module [11]. The information obtaining module communicates temperature information from sensors situated along the space to an equipment programmable regulator.

The synthetic research facility of the Organization of Burning Issues, for the creation of materials for the dental business, with three rooms, an area of 70 square meters, was picked as the premises. In this work, we utilized 13 sensors, these are temperature, moistness and tension sensors, which were put in each room, for more exact information estimation, and for preparing the neural organization. The motivation behind gathering information from these sensors was a checking framework, as indicated by which we will control the warming and cooling in the room. Three sensors would be hung in each room, these are DHT11 (temperature, dampness), CCS811 (pressure). Nonetheless, in enormous rooms, you can introduce sensors each 10 meters, and in little rooms - each 2-3 meters, and this won't essentially influence the outcome. The information from the sensors is gathered through the I2C convention to the regulator, we utilized the regulator - ESP32, then, at that point, the regulator by means of WiFi sent the information to the server in the MySQL data set, we conveyed our own neighborhood server in the labs. The information move rate has been decreased to 250 bytes/s because of impediments because of the qualities of the sending gadget. The Arduino Nano regulator is customized utilizing the Arduino IDE. The remote organization is utilized to communicate information to the expectation module. The information assortment module sends temperature information from sensors situated along the space to an equipment programmable regulator [11]. From the server, the expectation module sent on Raspberry PI, in the Python language, processes sensor information from the server and utilizations them to prepare the neural organization [11].

In this trial, we took just temperature information for preparing the neural organization, and we will utilize it to control warming and cooling in the room. In view of a pre-prepared LSTM neural model, the forecast module gives temperature circulation expectations to various methods of activity of the air conditioning framework. The dynamic module chooses the ideal temperature method of the warming and cooling framework to acquire the objective hotness conveyance work in the room and communicates the fitting order signs to the regulator to control the temperature.

The counterfeit neural organization (ANN) structure depends on the human sensory system and the learning system of the human cerebrum and neurons.

The In strategy incorporates a bunch of interconnected neurons partitioned into information, yield, and secret layers. The framework utilization is determined in light of the framework input and the organization weight, as well as the organization transmission work [11]. By adjusting this strategy to oneself help process, the ANN technique is broadly utilized in central air frameworks. The ANN practice is accomplished by changing the weighting element to diminish the expense work. An ANN Framework Distinguishing proof Model isn't needed. In view of the construction of non-straight capacities and articulations of information through the shells of interconnected neurons, the purported

counterfeit neural organizations or straightforward neural organizations, which are a typical technique for showing or showing associations among data sources and results. This can be an alluring decision for controlling and characterizing non-direct frameworks like central air frameworks. As indicated by Deponte and Grimaldi, the design or calculation of this strategy depends on a neurobiological framework. This implies that this technique should be visible as a black box with a ton of unsurprising power for the models. This is extremely helpful, particularly broadly utilized in obscure models or without a numerical model, or when all images are depicted in an obscure case and can prepare ANN [11].

To anticipate the activity of temperature sensors in the time series, two kinds of neural organizations were utilized. The first is a basic neural organization with a few secret layers, and the second is an intermittent neural organization (LSTM). A neural organization of the LSTM type was picked, since there are time information here, and this kind of neural organization is more ideal for this task [11].

As a module for information expectation and direction, we utilize a Raspberry PI single-board PC. On it, we send our neural organization and utilize the information recorded in the data set to prepare the neural organization. We split our tangible information into tests and train to prepare the neural organization [11].

The neural organization comprises of an information layer of 120 neurons (10 sensors x 12 time spans) and a first secret layer of 128 neurons, a second layer of 256 neurons, and a result layer of ten neurons, considering that the result 10 neurons are a forecast for every one of the ten neurons .

Information cleaning. In the data set, information was gathered from sensors for quite a long time. While composing temperature information to the data set, some of it contained commotion and mistaken information. Hence, as an example, we take information from ten sensors recorded with the right time list, and take an example in which the time series is accurately marked. We get an example where every one of the ten sensors are available. We likewise fill in information that contains mistakes. While cleaning the information, a few sensors showed a temperature of 150 or - 127 degrees, as the information is erroneous, so we sift through such commotion and select information under 40 degrees or more ten degrees Celsius.

As a model for the neural organization, we utilized an intermittent neural organization. The thought behind RNN is to involve data in a steady manner. Customary neural organizations accept that all sources of info and results are autonomous. Be that as it may, for some assignments this isn't appropriate. To foresee the following word in a sentence, it's ideal to think about the words that precede it. RNNs are called repetitive on the grounds that they play out a similar undertaking for every component of the grouping, and the outcome relies upon past computations. One more understanding of RNNs: these are networks that have a "memory" that considers past data.

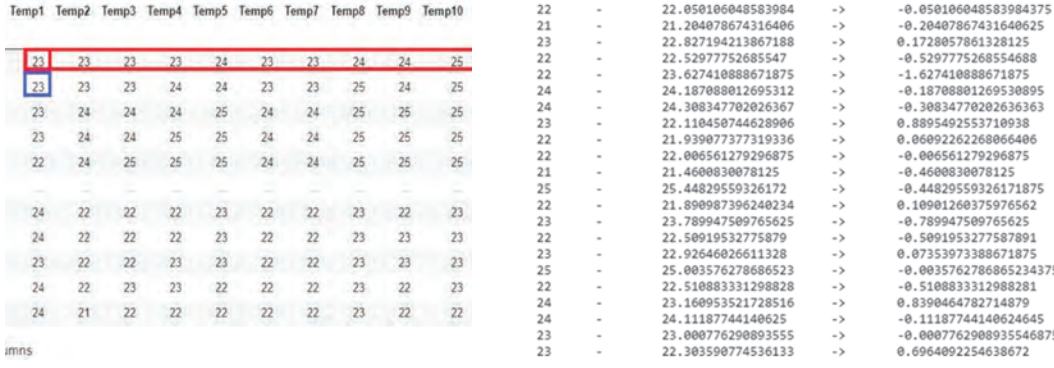
We utilized the Mean Squared Mistake (MSE) equation as the result work, and the SGD work as the enhancer.

The MSE-RMS expectation mistake is utilized in circumstances where we want to underscore enormous blunders and select a model that gives less huge forecast mistakes.

MSE - the standard mistake of the estimate is utilized in circumstances when we really want to underscore enormous blunders and pick a model that gives less huge figure mistakes.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2 \tag{3}$$

Forecasting and obtaining results from neural networks. In this way, we analyze the gauge of the neural organization and the genuine worth of the sensors in a given time stretch. In this diagram, we look at the genuine qualities and the qualities taken from the estimates. In the chart, we deduct the base worth from the greatest worth, then, at that point, it will be equivalent to 95-100 percent a model that gives less enormous conjecture blunders.



Temp1	Temp2	Temp3	Temp4	Temp5	Temp6	Temp7	Temp8	Temp9	Temp10
23	23	23	23	24	23	23	24	24	25
23	23	23	24	24	23	23	25	24	25
23	24	24	24	25	24	24	25	25	25
23	24	24	25	25	24	24	25	25	25
22	24	25	25	25	24	24	25	25	25
...	...	...	...	...	...	...	...	...	...
24	22	22	22	23	22	22	23	22	23
24	22	22	22	23	22	22	23	23	23
23	22	22	23	23	22	22	23	23	23
24	22	23	23	22	22	22	23	22	23
24	21	22	22	22	22	22	23	22	22

imns

```
22  -  22.050106048583984  ->  -0.050106048583984375
21  -  21.204078674316406  ->  -0.20407867431640625
23  -  22.827194213867188  ->  0.1728057861328125
22  -  22.52977752685547   ->  -0.5297775268554688
22  -  23.627410888671875  ->  -1.627410888671875
24  -  24.187088012695312  ->  -0.18708801269530895
24  -  24.308347702026367  ->  -0.30834770202636363
23  -  22.110450744628906  ->  0.8895492553710938
22  -  21.939077377319336  ->  0.06092262268066406
22  -  22.006561279296875  ->  -0.006561279296875
21  -  21.4600830078125    ->  -0.4600830078125
25  -  25.44829559326172   ->  -0.44829559326171875
22  -  21.890987396240234  ->  0.10901260375976562
23  -  23.789947509765625  ->  -0.78994750976562 5
22  -  22.50919532775879   ->  -0.5091953277587891
23  -  22.92646026611328   ->  0.07353973388671875
25  -  25.003576278686523  ->  -0.0035762786865234375
22  -  22.510883331298828  ->  -0.5108833312988281
24  -  23.160953521728516  ->  0.8390464782714879
24  -  24.11187744140625   ->  -0.11187744140624645
23  -  23.000776290893555  ->  -0.0007762908935546875
23  -  22.303590774536133  ->  0.6964092254638672
```

Figure 2 – Neural network prediction

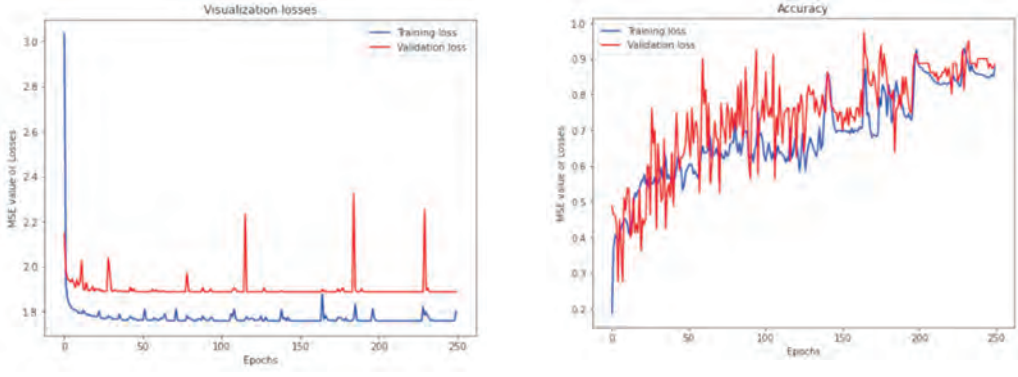
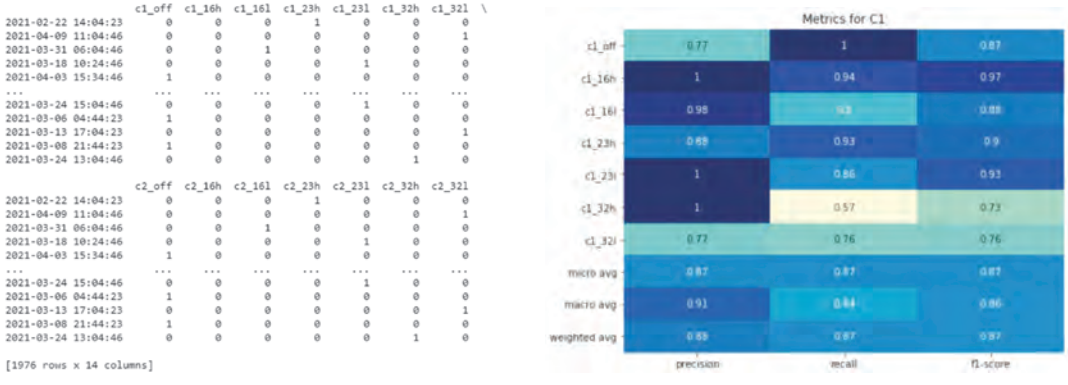


Figure 3 – Visualization losses



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                    c1_off  c1_16h  c1_161  c1_23h  c1_231  c1_32h  c1_321  \
2021-02-22 14:04:23       0       0       0       1       0       0       0
2021-04-09 11:04:46       0       0       0       0       0       0       1
2021-03-31 06:04:46       0       0       1       0       0       0       0
2021-03-18 10:24:46       0       0       0       0       1       0       0
2021-04-03 15:34:46       1       0       0       0       0       0       0
...                     ...     ...     ...     ...     ...     ...     ...
2021-03-24 15:04:46       0       0       0       0       1       0       0
2021-03-06 04:44:23       1       0       0       0       0       0       0
2021-03-13 17:04:23       0       0       0       0       0       0       1
2021-03-08 21:44:23       1       0       0       0       0       0       0
2021-03-24 13:04:46       0       0       0       0       0       1       0

                    c2_off  c2_16h  c2_161  c2_23h  c2_231  c2_32h  c2_321
2021-02-22 14:04:23       0       0       0       1       0       0       0
2021-04-09 11:04:46       0       0       0       0       0       0       1
2021-03-31 06:04:46       0       0       1       0       0       0       0
2021-03-18 10:24:46       0       0       0       0       1       0       0
2021-04-03 15:34:46       1       0       0       0       0       0       0
...                     ...     ...     ...     ...     ...     ...     ...
2021-03-24 15:04:46       0       0       0       0       1       0       0
2021-03-06 04:44:23       1       0       0       0       0       0       0
2021-03-13 17:04:23       0       0       0       0       0       0       1
2021-03-08 21:44:23       1       0       0       0       0       0       0
2021-03-24 13:04:46       0       0       0       0       0       1       0

[1976 rows x 14 columns]
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Figure 4 – Dataset of air conditioner working modes

As we can find in the above diagrams, forecast blunders decline essentially with every age of neural organization preparing and reproductions.

Subsequently, we think about the figure of the neural organization and the genuine worth of the sensors in a given time stretch. In these diagrams, we look at the genuine qualities and the qualities taken from the gauges. On the diagram, we take away the base worth from the greatest worth, then, at that point, it will be equivalent to 90-95%. In this paper, based on the prediction of temperature parameters, we have developed a neural network that allows you to control air conditioners in an intelligent optimal mode, in the form of a recommendation system. We tested this system and got excellent results. In the future, we will add data parameters of other gases and more input parameters to improve the scalability of the system.

Conclusion. In this research, combination of heating ventilation and air conditioning (HVAC) system was concepted by the architecture and the methods of optimization neural network. A model was built to optimize using HVAC system in the buildings. As a result of our research, we have developed an intellectual system that optimizes the problem of consumption and waste of heat supply and air conditioning in the room through a management and monitoring structure and an intelligent system model. The functionality of the system with the help of an intelligent automated system allows you to minimize human influence, increase the efficiency of the system, manage and control all the states in the system locally and remotely, analyze and examine data for a certain period of time, identify violations and failures of elements and sections of the system, optimize all work processes. The developed intelligent automated system solves the problems associated with the use of excessive heat and its costs, which allows the developed technology to function as a centralized system to supply heat to the room in the right amount and turn on air conditioning all year round, regardless of the time of day and weather conditions. The use of monitoring and regulation of the set parameters allows the intelligent system to provide electricity only in the amount in which it is needed and at the same time save unnecessary consumption. The system is easily scaled and can run for many years without interruption and is safe for the environment.

This research was funded by grant of Ministry of Education and Science of the Republic of Kazakhstan №AP09260767 “Development of an intelligent information and analytical system for assessing the health status of students in Kazakhstan” (2021-2023).

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МАШИНАЛЫҚ ОҚЫТУ КӨМЕГІМЕН ЖЖАБ ЗИЯТКЕРЛІК ЖҮЙЕСІН ӘЗІРЛЕУ

Мақала бөлмедегі жылумен жабдықтауды және ауаны баптауды реттеу мәселесіне арналған. Датчиктердің динамикалық сипаттамаларын бақылаудың автоматтандырылған жүйесі сипатталған, ол сынақ стендін орнатуға және температураны динамикалық бақылау және ауаны баптау датчиктерінің параметрлерін талдауға арналған бағдарламалық-аппараттық кешен болып табылады. Бұл жүйенің негізгі мақсаты-ауаны баптау және температураны ұстап тұру арқылы бір бөлмені автоматтандыру. Жүйе Google Coral USB үдеткішін басқару, ADC параметрлері және температура датчиктерінің, қосқыштардың, ағып кету датчиктерінің және ауа баптау датчиктерінің амплитудалық-жиілік және фазалық сипаттамаларын сенсорлардың динамикалық сипаттамаларын бақылау және бақылау үшін стендтегі эксперименттік зерттеулерінің нәтижелері негізінде анықтайды. бағдарлама SCADA Genesis64. Сынақ стендінің схемасы, жүйенің жалпыланған алгоритмі және бағдарламаның экрандық нысаны ұсынылған. Ішкі температураны бақылау және ауаны баптаудың автоматтандырылған жүйесінің бағдарламалық жасақтамасы ModBus TCP, OPC UA және SCADA бағдарламалары негізінде жасалған.

Түйін сөздер: *SCADA Genesis 64, интеллектуалды жүйе, Машиналық оқыту, нейрондық жүйелер, ауа баптау жүйесі.*

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РАЗРАБОТКА ИНТЕЛЛЕКТУАЛЬНОЙ СИСТЕМЫ УПРАВЛЕНИЯ СИСТЕМОЙ ОВИК С ИСПОЛЬЗОВАНИЕМ МАШИННОГО ОБУЧЕНИЯ

Статья посвящена проблеме регулирования теплоснабжения и кондиционирования воздуха в помещении. Описана автоматизированная система контроля динамических характеристик таких датчиков, представляющая собой программно-аппаратный комплекс для настройки испытательного стенда и анализа параметров датчиков динамического контроля температуры и кондиционирования воздуха. Основной целью этой системы является автоматизация одной комнаты путем управления кондиционированием воздуха и поддержания температуры. Система выполняет функции управления USB-ускорителем Google Coral, настройки АЦП и определения амплитудно-частотных и фазочастотных характеристик датчиков температуры, переключателей, датчиков утечки и кондиционирования воздуха на основе результатов их экспериментальных исследований на стенде для контроля динамических характеристик датчиков и мониторинга в Программа SCADA Genesis64. Представлена схема испытательного стенда, обобщенный алгоритм работы системы и экранная форма работы программы. Программное обеспечение автоматизированной системы контроля температуры и кондиционирования воздуха в помещении разработано на основе программ ModBus TCP, OPC UA и SCADA.

Ключевые слова: *SCADA Genesis 64, интеллектуальная система, машинное обучение, нейронные системы, система кондиционирования воздуха.*