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DATA PROCESSING ALGORITHM IN REMOTE MONITORING SYSTEM FOR RAW COTTON BUNTS STORED IN WAREHOUSES

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Abstract:

Objective. In order to properly organize good and high-quality storage of raw cotton bunt a long time, it is necessary to divide the cotton into groups, taking into account its moisture content. This article analyzes the remote monitoring of fire hazard indicators (temperature, humidity) for high-quality and safe storage of raw cotton bunts. Algorithm and descriptions of remote monitoring system operation are presented.

Methods. Due to the increase in temperature and humidity of the raw cotton bunt, it has been observed that its quality deteriorates, and it even causes a fire by itself due to heating. As a result, the cotton becomes unusable, which causes great economic damage. In order to prevent these situations, a remote monitoring system was developed.

Results. The structure of the remote monitoring system consists of a device capable of transmitting the results obtained from humidity and temperature sensors in real time from two separate wireless transmission modules. This device transmits data to the Wi-Fi, GSM monitoring center.

Conclusion. The remote monitoring system provides an opportunity to obtain information about the humidity, temperature, and battery power level of the cotton stored in warehouses. It can be widely used to reduce the negative effects on the quality of cotton raw materials stored in warehouses and to prevent the risk of fire.

Keywords: cotton barn, raw cotton bunts, temperature, humidity, Wireless sensor networks, GSM, Wi-Fi, ZigBee, Bluetooth, monitoring system, database, SMS, mobile application, web application.

Introduction. Today, the cotton industry is highly developed in the main cotton-growing countries such as China, USA, India, Pakistan, and Turkey. The Republic of Uzbekistan is among the top ten countries in the world in terms of cotton production, and among the top five countries in terms of cotton fiber quality [14]. There are more than a hundred cotton ginning enterprises and more than four hundred preparation facilities for receiving and seasonal storage of cotton harvest in the republic, where raw cotton is stored for 3-6 months. Constant control and monitoring of temperature and humidity of raw cotton during storage is very important to prevent negative situations [15].

In the cotton mills of Uzbekistan, the temperature and humidity of the cotton are monitored daily by the responsible staff using the devices, and by recording the indicators on the devices in the prescribed form. Including, for high-quality, fire-safe storage of cotton bales stored in open and closed warehouses, it is necessary to constantly measure the temperature and humidity of seed cotton. Various devices are used for monitoring and measuring. It is necessary to carry out measurements with the help of devices and to determine the indicators, to implement the prescribed measures when exceeding the standard condition. In some cases, the number of measuring devices, the time it takes to obtain the results, the calculation of the values of the obtained measurement results, the excess labor force, manual labor, and control are complicated. In addition, when negative situations are detected, quick decision-making, elimination and pre-estimation are very important. It serves to increase work productivity through the use of a remote monitoring system in production enterprises, warehouses, and greenhouses.

Methods. Closed warehouses, semi-open or four-sided open warehouses (porches) and specially prepared outdoor areas are used for cotton storage. A number of prescribed measures are implemented to maintain the quality of

cotton [18]. However, due to adverse weather conditions, precipitation and technical reasons, a part of the cotton grown each year (about 2.5-3%) may be of poor quality due to the temperature and humidity in the cotton gins, as well as due to technical safety. [16]. The dimensions of the garden areas are 25x14 m, the height should be 0.4 m above the ground level, and it should be raised by 0.05-0.07 m to ensure the drainage of rainwater. (Figure 1).

a)

b)

Figure 1. Raw cotton bunts stored in the open field: a) the appearance of the initial acceptance, b) the appearance of precipitation in the winter season.

Table 1

Technical characteristics of raw cotton during preparation

Cotton variety	Cotton moisture, percent	The height of the cotton pile, meter	Approximate mass of raw cotton in the area, tons
I	**up to 9**	**8**	**400**
	9,1-12,0	**8**	**350**
	12,1-14,0	**7**	**300**
	above 14	6	250
II	**up to 10**	**8**	**370**
	10,1-13,0	**8**	**300**
	13,1-16,0	**7**	250
	above 16	6	200
III	up to 11	7	350
	11,1-15,0	7	300
	15,1-18,0	6	230
	above 18	6	200
V	**up to 13**	6	**270**
	13,1-17,0	5	**200**
	17,1-20,0	4	190
V	above 20,1	4	60-90

In order to properly organize good and high-quality storage of raw cotton for a long time, it is necessary to divide the cotton into groups, taking into account its moisture content. When the moisture content is up to 14%, it can be packed into shards. The technical characteristics of cotton when packed into garams should not exceed the following indicators (Table 1) [6].

At the same time, measuring and controlling the temperature of raw cotton bunts is carried out by a group of supervisors consisting of 5-6 people. In this case, the supervisors record the temperature at eight points of the bunts where the measurements were made, and based on this, they determine the average temperature of the raw cotton bunts. It takes a long time, measuring one cotton bales takes about 3-4 hours. It takes a lot of time for measurements, causes a lot of complications in determining it in the case of sudden changes in temperature and humidity inside the chamber as a result of external influences. If only the temperature of the cotton bales is measured [9], the remote measurement device developed and used in the experimental tests gives the possibility to measure the temperature and humidity at the same time Fig. 2.

Due to the increase in temperature and humidity of the aw cotton bales, it has been observed that its quality deteriorates, and it even causes a fire by itself due to heating. As a result, the cotton becomes unusable, which causes great economic damage. In order to prevent these situations, a remote monitoring system was developed [10].

Today, wireless sensor networks WSN (Wireless Sensor Networks - wireless sensor networks) are used for remote monitoring [19]. Monitoring based on WSN is aimed at obtaining measurements of temperature, pressure, wind speed, humidity and other parameters, remote control, and processing of the obtained results. Therefore, the transmission of information from devices through communication networks provides control, early detection of negative situations, and effective management [1].

WSN is a network of sensors that monitor and record the physical state of the environment and transmit the collected data to the center via radio waves. Data obtained from WSN can be organized as wireless transmission and wireless ad-hoc

networks [5]. A WSN is bidirectional and allows for data collection and sensor operation management. Such networks are used in production process control, system monitoring, agricultural, industrial and user applications [4].

Using WSN, dedicated sensors are used to measure the temperature and humidity of cotton bales. In wireless sensor networks, many wireless technologies such as Wi-Fi, Bluetooth, ZigBee are used for data transmission and network organization. The technical characteristics of these wireless technologies are presented in Table 2 [2].

Table 2.

Analysis of specifications of wireless technologies

Technical characteristics	Wireless technology name		
	Wi-Fi	ZigBee	Bluetooth
Operating distance	100-150 m	50-1600 m	10-100 m
The number of nodes in the network	2007	264, 65536	8
Power supply	12-24 hours	12-14 months	6-12 months
Connection time	3 sec	30 ms	10 sec
Type of communication	DSSS	DSSS*	FHSS**
Frequency range	2.4GHz, 5GHz	850-930MHz	2.4 GHz
Data transfer speed	300-600 Mb/s	250 kbps	10 Mb/s

Results. It is sufficient to measure the temperature and humidity of the observed raw cotton bunts once a day. The proposed monitoring system was developed taking into account the need for information, along with daily measurements, when the indicators increase or decrease from the specified norm [7]. In order to compare the developed device and the currently used ТЭ-100 thermoshup [8] device, an experimental test was conducted to measure the temperature of raw cotton bunts (Fig. 3).

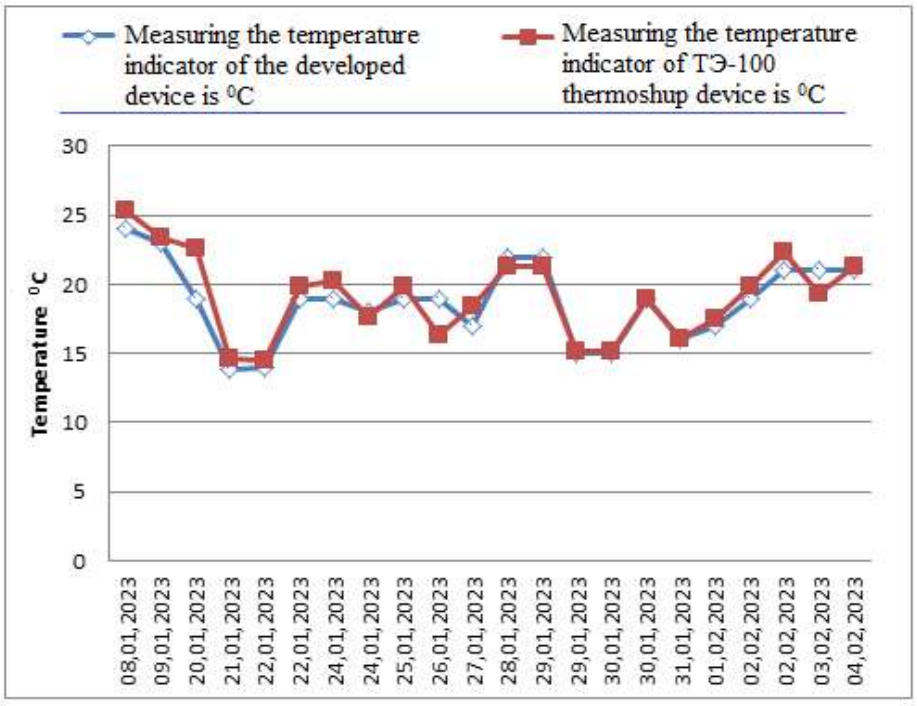

Figure 3. Test graph for measuring the temperature of cotton bunts

The results from the devices showed a measurement error of up to 1^0C. However, the developed device showed advantages over the analogue device in practice, as it required less time to obtain the result during the pilot-testing period and to transmit data to the remote monitoring system.

The structure of the remote monitoring system consists of a device capable of transmitting the results obtained from humidity and temperature sensors from the network in real time from two separate wireless transmission modules (Fig. 4). This device transmits data to the Wi-Fi, GSM monitoring center [11,12].

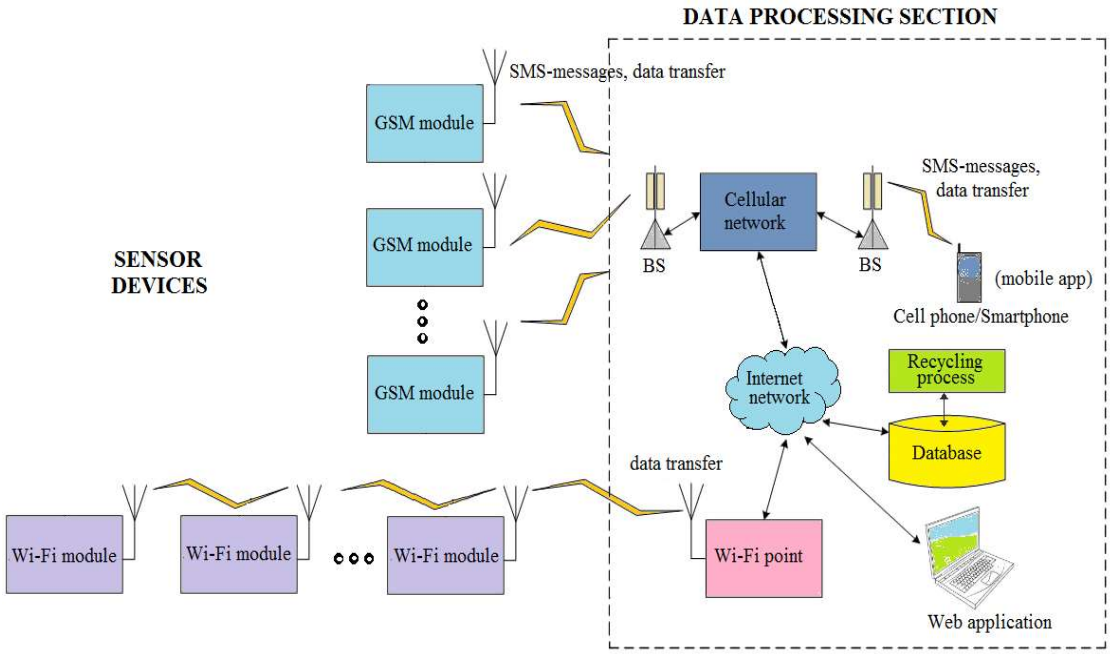

Figure 4. Remote monitoring system of temperature and humidity of raw cotton bunts warehouses

The developed remote monitoring system consists of sensor devices installed on cotton bales and a computer server connected to a wireless network. In case of increase or decrease from the target value, the results will be provided remotely. The received pointers are saved to the database after processing. The data reflecting the current status of the monitoring system is based on statistical analysis and is displayed in the web application and the mobile application. The data is transmitted to the monitoring center and the system provides the operator with online and temperature and humidity data from the monitored equipment for real-time display [13].

Thus, the operator has the latest and most accurate information about the indicators received from the monitored devices. A monitoring system algorithm was developed to control the operation of the monitoring system and process the data of its devices [17].

The data processing algorithm of the remote control devices of raw cotton bunts warehouses is presented in Fig. 5.

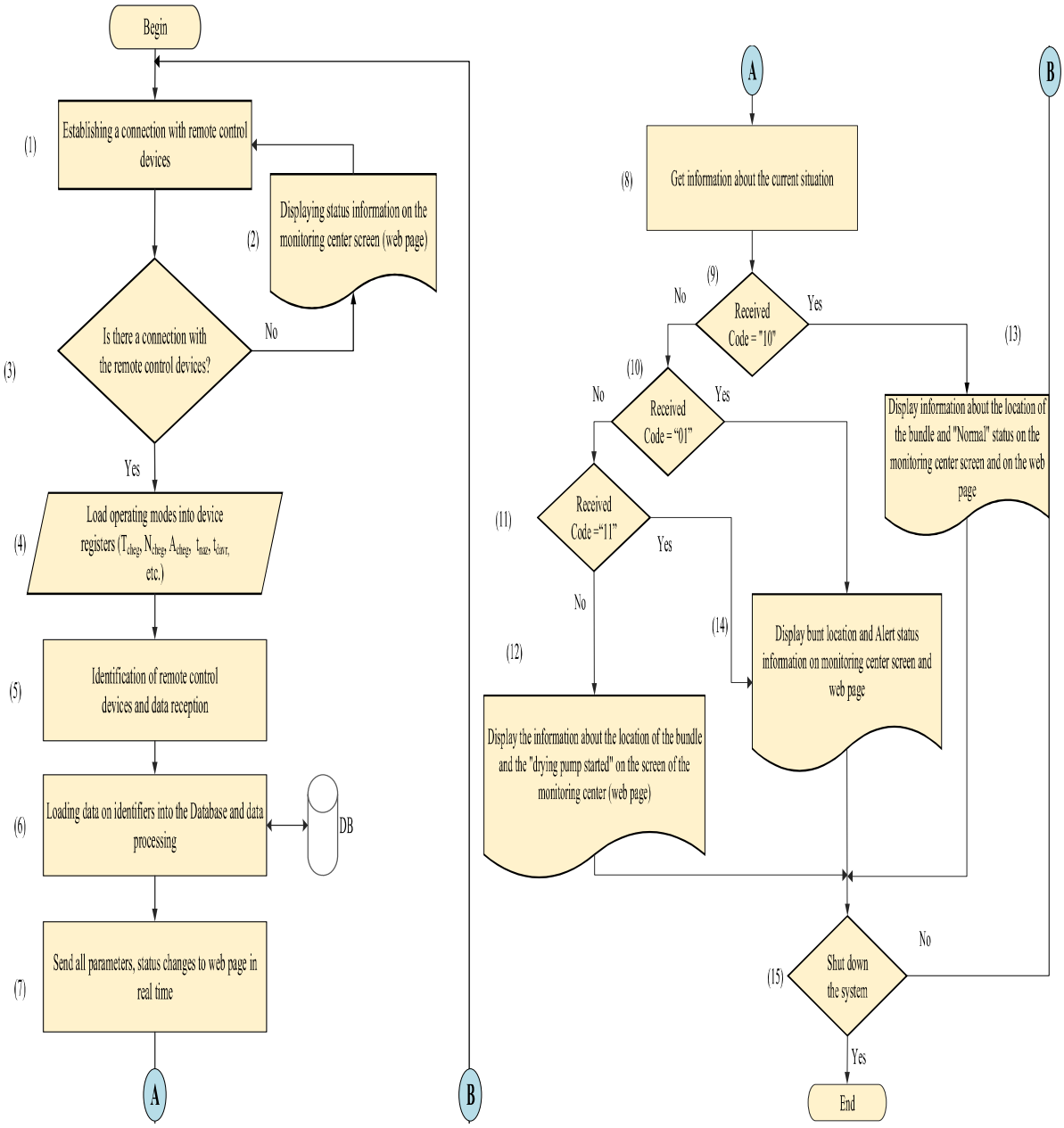

Figure 5. Algorithm of data processing of remote control devices of raw cotton bunts warehouses. (1st version)

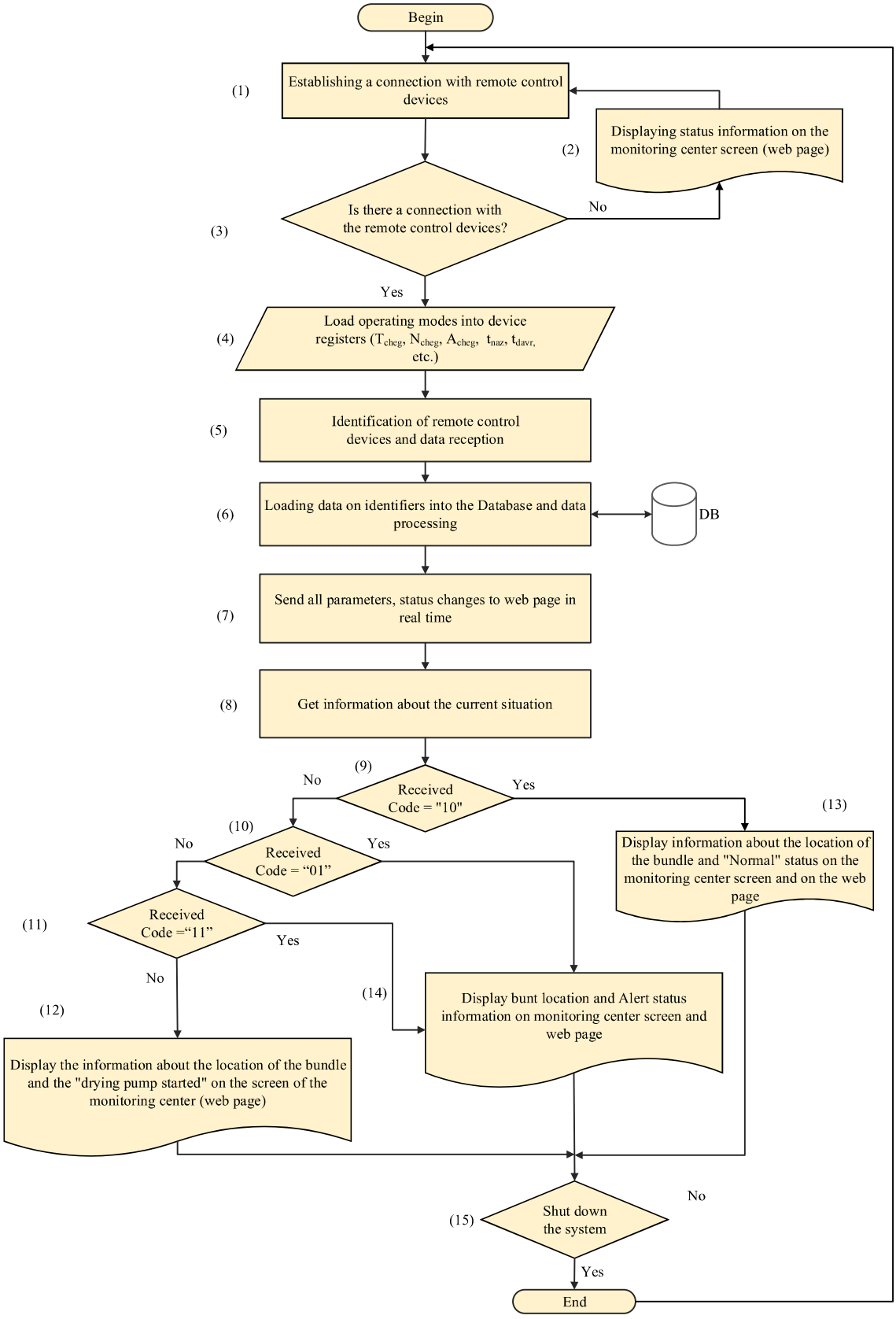

Figure 5. Algorithm of data processing of remote control devices of raw cotton bunts warehouses

The sequence of operation of the proposed algorithm for data processing of remote control devices of raw cotton bunts warehouses and the block diagram of the algorithm are presented in Figure 5. The sequence of operation of the algorithm:

Step 1. Establishing a connection with remote control devices

Step 2. Displaying status information on the monitoring center screen (web page).

Step 3. If communication with remote control devices is available, go to step 4, otherwise go to step 2.

Step 4. Operating modes (T_{cheg}, N_{cheg}, A_{cheg}, t_{naz}, t_{davr}, etc.) are loaded into device registers.

Step 5. Device operating modes (date, control time, periodicity, etc.) are loaded.

Step 6. Identification and data of remote control devices are accepted.

Step 7. Data on identifiers (DB) is loaded into the database and the data is processed.

Step 8. Get information about the current situation.

Step 9. If Received Code = “10” go to step 13, otherwise go to step 10.

Step 10. If Received Code = “01” go to step 14, otherwise go to step 11.

Step 11. If Received Code = “11” go to step 14, otherwise go to step 12.

Step 12. Information about the location of the bundle and the fact that the "air suction pump has started" is displayed on the screen of the monitoring center (web page).

Step 13. Information about the location of the bundle and the “Normal” status is displayed on the monitoring center screen and on the web page.

Step 14. Bunch location and Alert status information is displayed on the monitoring center screen and web page.

Step 15. If it is necessary to terminate the system operation, the operation is terminated, otherwise it goes to step 1.

The data processing algorithm of remote monitoring devices takes into account the amount of precipitation, changes in the temperature and humidity of the warehouse where cotton is stored, the amount of battery power, time control, periodicity, changes in the operating mode and other conditions during developed [12].

Discussions. The controller can download the current status of the monitored raw cotton goods, and if necessary, the daily, weekly or monthly report from the system in electronic form. In addition, the statistical data stored in the database are displayed graphically (Figures 6, 7).

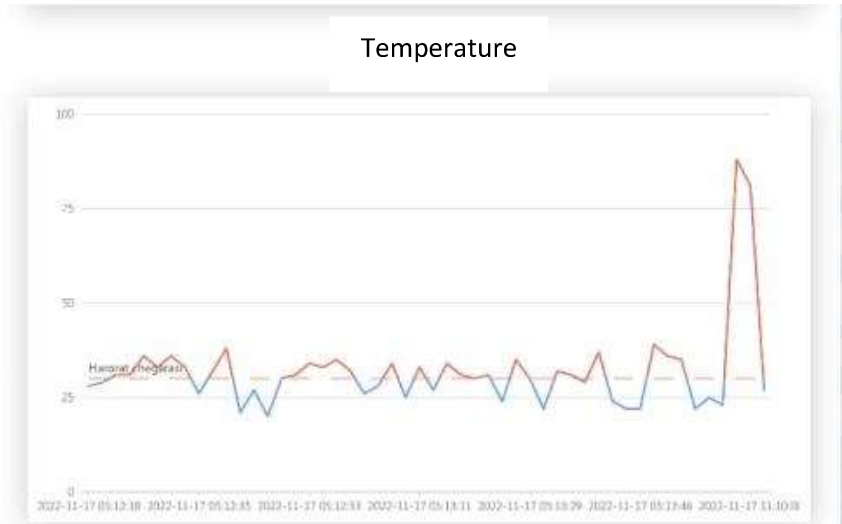

Figure 6. Graphic display of the temperature of the observed raw cotton balls in the web application

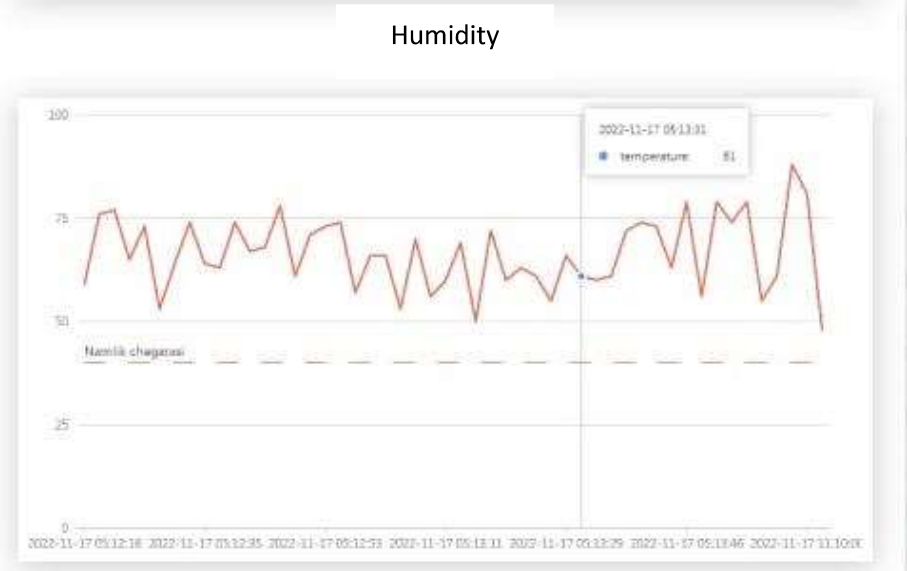

Figure 7. Graphic representation of the moisture content of the observed raw cotton bales in the web application

In the monitoring system, the controller can see the temperature and humidity, the capacity of the device, or receive information in the form of an SMS-message by sending a request through a mobile device.

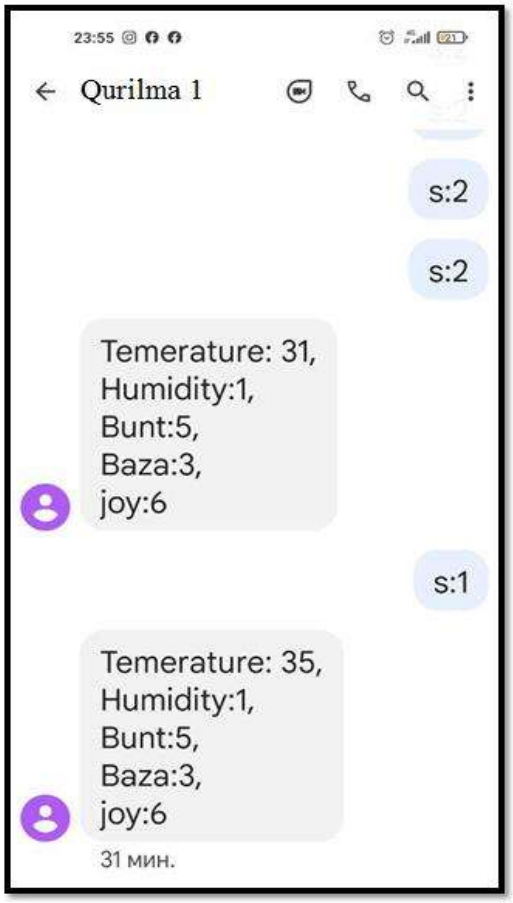

Figure 8. Receive information about the temperature and humidity of raw cotton bunts in the form of an SMS-message

Also, an automatic warning function is required in case of exceeding or decreasing the specified values. The system sends emergency warning messages to operators in the form of an SMS-message and simultaneously in the form of a warning message in the web application [20]. The supervisor who received this message gives an opportunity to develop practical measures and eliminate negative situations in a timely manner [21].

Conclusion. Based on the data processing algorithm of the system of remote monitoring of the raw cotton warehouses condition, measuring the fire hazard indicators of raw cotton bunts, the impact of the environment, receiving, processing and timely measurement results of the developed devices notification, implementation of appropriate measures in necessary cases, and most importantly, the operation of the monitoring system based on wireless technologies was achieved. All parameters related to system performance are fully covered. The remote monitoring system collects information about the humidity, temperature, and battery power of the device stored in warehouses. It allows to configure, evaluate, and predict operating modes using wireless networks. It can be widely used to reduce the negative effects on the quality of cotton raw materials stored in warehouses and to prevent the risk of fire.

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