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DEVELOPMENT OF A MULTI-MEASURING SYSTEM FOR CONTROL AND PREDICTION OF PROCESS WATER RESOURCES ON THE ARDUINO PLATFORM

E.Ozodov, N.Ozodova, D.Tadjiyev - "TIIAME" National Research University, Kari-Niyoziy-39, Tashkent, Uzbekistan

Abstract

Implementation a multi-dimensional water resource measurement system and machine learning (machine learning) neural networks, it is possible to predict possible water resources based on available current data and make smart use of existing water resources. The above article focuses on the application of multiscale systems to closed lake systems. The article provides information about the monitoring complex based on the ATmega 328e platform and its architectural features. The real-time monitoring software used in the system reports its architecture and preliminary experimental results of the system implementation.

Keywords: *automatic monitoring system, real-time monitoring, forcasting system, water quality, remote sensing, microelectronics, irrigation system, data automation.*

Introduction. Research of the world's largest lakes and reservoirs shows that more than half have declined since the early 1990s. The total rate of water loss in these lakes over almost three decades was about 22 gigatons per year, which is approximately 1.4 times the volume of Aidarkol in Uzbekistan. The main reason for this was climate warming and partly improper use of water. Surprisingly, significant water losses were observed not only in arid but also in humid areas. This situation directly affects the nearly 2 billion people living in dry lake basins and is leading to water shortages in many regions.[1]

Aidarkol is an artificial lake located in the Arnasoy lake system in the northeastern part of Uzbekistan. The lake was formed in the late 1960s mainly as a result of excess water runoff from the Chordara reservoir in southern Kazakhstan. The lake is located in Jizzakh and Navoi regions. The northern shores of Khaidarkol adjoin the Eastern Kyzylkum. The lake is 159 km long and 26 km wide. In 2005, Khaidarkol had 44.3 km³ of water. Currently, the area of the lake is about 3000 km²(see. Figure 1).[2]

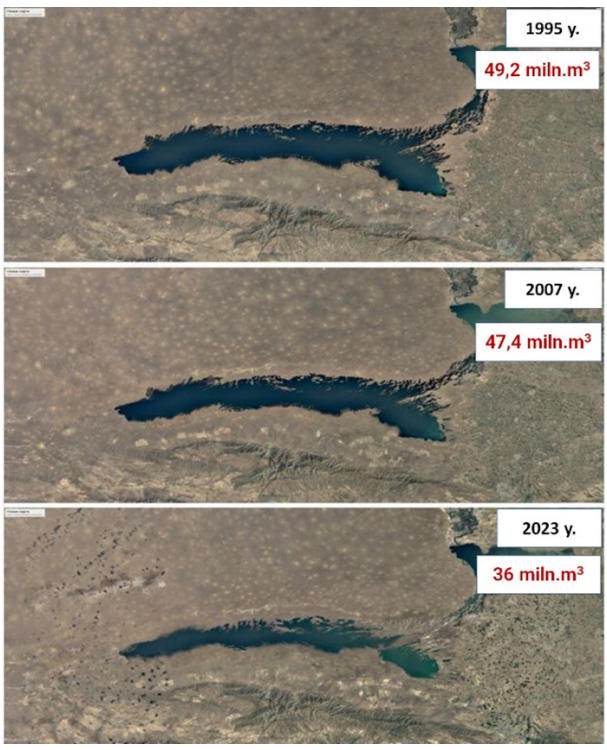


Figure 1 Reduction of the perimeter and volume of water in Lake Aydar

Due to the lack of organisation of the water distribution system and control of incoming and outgoing water, the volume of water decreased from 44 billion m^3 in 2000 to 34 billion m^3 in 2023.[3]

The loss of the above water resources could have a negative impact on economic performance, including the 10 billion m^3 water resource of Aidarkol, which is generally wasted due to lack of allocation and control, if this resource was used for planting cereals we could have a harvest of 4 million tonnes and this would generate a profit of 115290000 (USD).

To prevent such economically extensive allocation of resources and to save water resources, it is advisable to use systems with low power consumption and continuous monitoring capability.

The main objective of the system is to be able to consider the state of the resource and the possibilities of its utilisation based on the parameters of water sources, in which case the system can be considered alternative and optimal.

If this situation persists, it will harm the flora and fauna of the area from an ecological point of view, reduce the water supply to the population and land reclamation. From an economic point of view, it has a negative impact on industries that directly depend on the lake, such as tourism and fishing. Changes in microclimate lead to increased temperature and wind changes. Dust and soil erosion become problems that degrade air and land quality. In conclusion, the environmental, economic, social and cultural impacts of the drying up of Lake Aidarkol point to the importance of developing a system for predicting the quantity and distribution of water resources.

Methods of water balance regulation in lakes:

- Water level sensors show over time changes in the lake's water level;
- Precipitation measuring equipment assesses changes in water quantity;
- Evaporation measurement devices at the lake level provide information on how much water is being lost by evaporation.;
- Flow sensors installed in the lake's tributaries show how much water has flowed in and out of the lake;
- Water quality sampling is used to monitor chemical and biological parameters and determine the water quality of the lake;
- Remote sensing provides spatial information on lake shore width and surface temperature via satellite;

- Hydrological models integrate monitoring data to estimate the components of the water balance.

These methods help to understand the water dynamics in the lake and make decisions on sustainable use of water resources. But these methods have their shortcomings, e.g:

- Water level sensors do not show the overall level because they measure the level at a specific point:
- Rain gauges sometimes don't show the true rainfall in an area. They might make it look like it rains more or less in certain places than it really does;
- Since measuring evaporation at lake level is a difficult task, measurement errors occur;
- Because large lakes are complex hydrological systems, it is not possible to install a sensor on every tributary;
- Water quality sampling requires routine and costly field work, and results may not reflect real-time conditions;
- Special authorisation is required to use remote sensing and data cannot be obtained in cloudy weather;
- Hydrological models are based on assumptions and simplifications that may introduce uncertainties.

After studying these drawbacks, we developed a system that can provide information about changes in the lake water balance in real time, remotely, as well as forecast the volume of water resources of the lake in the future using past data. The developed system and control equipment take into account 8 factors and, summing them up, forecast the volume of water sources before the irrigation season with the help of a special programme.

The advantage of the system over other methods is that it can make decisions by examining data remotely in real time.

RESEARCH METHODOLOGY

In water resources control based on the principle of data automation, it is possible to predict water resources by setting a data limit, for this reason it is advisable to use the following research methods: it will be possible to achieve the result by active experimentation, unconditional optimisation and modelling.

Statistical analysis and the use of mathematical modelling models and remote sensing techniques are used to analyse the given data and interpret the data [4,5].

Given that operational data analysis will be performed at a site covering a large area, the implementation of IoT-based high-speed communication technologies (LoRaWan) is aimed at maximising operational analysis [6].

STUDY RESULTS

The analysis of data in a given control system based on two main features increases its adequacy.

For data analysis, forecasting methods based on orthogonal discrete Laguerre polynomials can be used to monitor the water resources of drainless lakes in the following tasks:

1. Mathematical modeling and forecasting of aquatic ecosystems. This makes it possible to create mathematical models capable of predicting the behavior of aquatic ecosystems based on historical data and current conditions.

2. Flexible forecasting. This method allows them to adapt to changing conditions and update their forecasts according to new information, and also ensures the relevance and accuracy of the information provided.

3. Forecasting of nonstationary random processes.

4. Consideration of anthropogenic impact makes it possible to make a final forecast conclusion and then make a decision based on the results of the analysis[14,15].

5. Optimization of forecast errors. Forecasting methods based on orthogonal discrete Laguerre polynomials can be used to minimize forecast error and improve forecast accuracy [16].For систем closed lake systems, orthogonal discrete Lager polynomials can be applied and interpreted as follows:

$$Y = f(pH, L, P, T, S, M, W, D, C, S) = a_0 + \sum_{i=1}^{n} a_i L_i(X) \quad (1)$$

B Formula (1) explains the accounting of basic water resources.

Y – the predicted value (for example, the volume of water resources or the state of the lake).

f is a function that describes the relationship between Y and the input parameters.

pH,L,P,T,S,M,W,D,C,S — input parameters (water pH, water level in saturated lake springs, lake humidity perimeter, water temperature, salinity, turbidity, water consumption, pollution level, climate change, socio-economic factors).

a 0 , a ai – coefficients determined during sample training,

Li(X) orthogonal discrete Lager polynomials,

X is a vector of input parameters.

n is the number of polynomials used.

By calculating these parameters, we can determine the available resources and the factors that affect them [7, 8].

By creating a program for calculating this model in the Python programming Python language, the adequacy of the model was determined by determining the amount of precipitation in the Aidarkol system for 2023 and comparing it with real indicators (Figure 2).

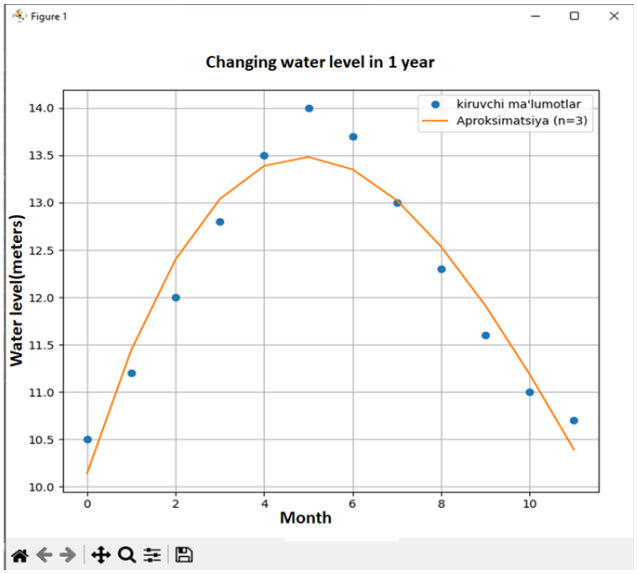


Figure 2. Chart of water level changes in the Aidarkol drainless lake system in 2023.

A multi-management system is necessary for managing technological processes in the process of forecasting and rational distribution of water resources through a given system.

The main task of the multi-control system is to fully organize the input parameters for using discrete Lager polynomials [9, 10].

The control system sets 10 parameters and 8 physical measurement parameters.

Monitoring water quality in a closed lake system at one point leads to errors, for example, water concentration and

pH are different at different points on the water surface.

At the same time, a single set of water monitoring sensors is used (Fig. 3).

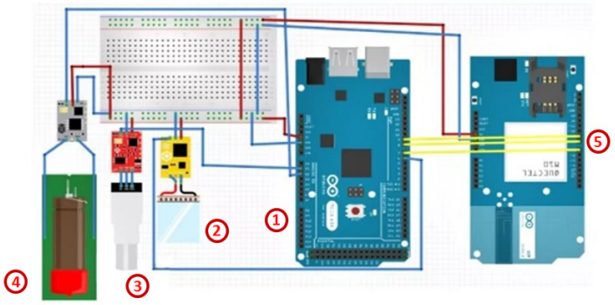


Figure 3 shows the Arduino water monitoring architectureArduino.

1-ATmega 328 E Microprocessor Programmable Logic Controller (PLC) ATmega 328e2-Keyestudio V1.0 Turbidity sensor 3-pH sensor 4-TDS sensor 5-GSM D-900 module

In addition, to determine the humidity perimeter in closed lake systems, installing a network of hygrometric sensors on the surface of the humidity perimeter increases the accuracy of the results and it is necessary to implement an autonomous measurement process [11, 12].

The hygrometric sensor should enable the use of a LoRaWAN network based on solar panels and an IoT system, so the following scheme is proposed (Figure 4).

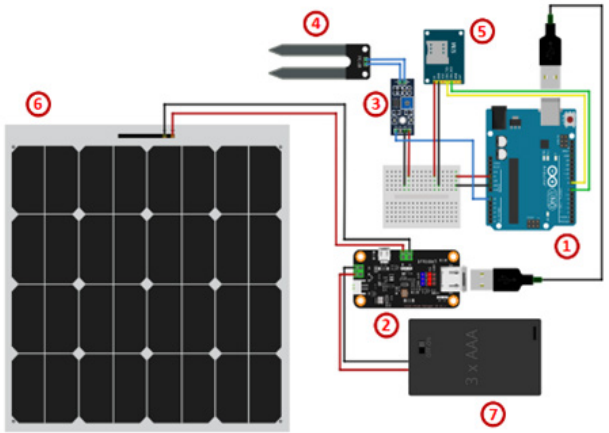
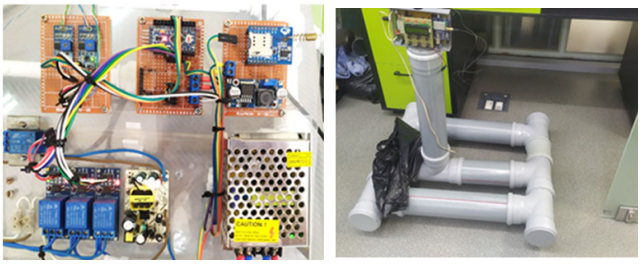


Figure 4 the architecture of an Arduino-based humidity monitoring device.

1-ATmega 328E processor controller 2-Accumulation process control module (RF433MHz RF transmitter) 3-YL-69 hybrid signal module 4-YL-32 screw 5 -D12 GSMmodule 6-Solar panel

Data can be analyzed using management tools based on the proposed architecture. In this case, the possibility of predicting the volume of resource formation increases due to the formation of the ratio of the perimeter of humidity and water saturation coefficients.

Preliminary results were collected based on an experimental model. In the experimental model, information was obtained and analyzed based on the GSM module in the CDMA protocol (Fig. 5).



a) b)

Figure 5. Prototype of multi-measurement system control.

a) architecture of the monitoring equipment b) design of the shielded transmitter

Conclusion

In this article, we investigated multisensory systems for detecting and predicting water resources. These systems play an important role in water resource management, especially in changing climatic conditions.

The main points discussed in the article:

1. Determining the perimeter of wetlands. Multisensory systems allow accurate identification of wetland boundaries, which is important for effective water resources management.

2. Consideration of other factors: in addition to moisture, systems take into account climate change, water consumption, and the intensity of water runoff. This allows you to more accurately predict the volume of water.

3. Recommendations for water use: Multi-sensor systems provide recommendations for using water without negative consequences for its source. This is important for the sustainable management of water resources.

Disadvantages and additional recommendations:

* Accuracy of calibration. To achieve more accurate results, you must carefully calibrate the sensors and take into account possible data distortions.

* Integration with other systems: Moisture detection systems should be integrated with other monitoring systems, such as weather stations and hydrological sensors.

* Consider the impact of human activities: It is important to consider the impact of human activities on water resources, such as agriculture, industry, and urban development.

In general, multisensory systems are a powerful tool for detecting, predicting and managing water resources, and their application can contribute to more efficient use of water in the future.

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