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A. Mustafayeva

Mingachevir State University, Mingachevir, Azerbaijan
Institute of Control Systems, Baku, Azerbaijan
e-mail: aida.mustafayeva@mdu.edu.az

DEVELOPMENT OF INTELLIGENT WEB APPLICATIONS FOR AUTONOMOUS CONTROL OF ROBOTIC DEVICES (IN THE FORM OF MULTIDIMENSIONAL OBJECTS) IN THE AGRICULTURAL SECTOR

Abstract. Global agricultural challenges, including those faced in Azerbaijan, encompass climate change, water scarcity, irrigation difficulties, soil degradation, biodiversity loss, rising production costs, market uncertainty, labor shortages, and concerns around food safety and quality. These issues pose significant obstacles to the sustainable development of agriculture and demand innovative solutions. Climate change, for instance manifested – in rising temperatures and increased extreme weather events – creates an uncertain and often unfavorable environment for farmers. In Azerbaijan, the Presidential Decree dated July 15, 2021, on measures to promote agricultural production and processing, has established favorable conditions for the effective deployment of smart web applications designed for intelligent agricultural process control, as discussed in the article. The article explores several key areas of this decree, aligning them with the objectives of advancing smart technologies in agriculture. These proposed web-based solutions aim to enhance the automation, improvement, and efficiency of agricultural processes, and they are well-supported by government policies and incentives aimed at stimulating Azerbaijan's agricultural sector.

Key words: web application, mechatronic robotic devices, UX/UI design, agricultural sector, Intelligent web applications, Multidimensional objects, Smart farming.

1. Introduction

The article proposes technologies for designing a remotely controlled web application to manage an autonomous control system for mechatronic devices, aiming to help agriculture adapt to changing climate conditions and improve sustainability. By using intelligent robotic devices controlled through web applications, it is possible to optimize water usage, reduce losses, and manage irrigation efficiently, while also quickly responding to market changes and addressing labor shortages.

The UX/UI design of these web applications, which provide remote configuration and enable the transfer of an intelligent knowledge base via Bluetooth and Wi-Fi technologies, allows the system to adapt dynamically to the evolving agricultural sector. This adaptability increases sustainability, efficiency, and productivity. Such applications empower farmers to monitor and adjust control parameters in real time, which is particularly valuable in remote agricultural areas.

Moreover, integrating remote configuration and knowledge-sharing capabilities across a group of intelligent robots that can act collectively generates a synergistic effect. This improves control quality and enables the acquisition of new experiential knowledge through robot-to-robot interactions.

A well-thought-out UX/UI design is crucial for the successful implementation of these technologies. A user-friendly and intuitive interface enhances farmers' workflow by providing quick access to essential information and control functions. The web applications are designed to be compatible across multiple devices and platforms to ensure widespread accessibility and usability in the field.

2. Methodology

With the acceleration of digitalization, the global agricultural industry is actively adopting smart web technologies to improve production efficiency and sustainability. The development of these technologies largely depends on each country's unique conditions, such as climate, legal frameworks, and economic priorities. For instance, countries with arid climates, like Israel, focus on developing smart agricultural technologies that optimize water usage and minimize waste. Countries with fertile soil and favorable weather, like France, prioritize enhancing product quality and implementing automated control systems.The improvement of existing decision-making systems for farmers – such as access to credit, insurance, and markets–in collaboration with government and public institutions, is essential. The decree of the President of the Republic of Azerbaijan, dated July 15, 2021, emphasizes the successful implementation of smart agricultural systems, creating favorable conditions for the applications proposed in the article, which can be outlined as follows [1], [2]:

1. Improving infrastructure and digitalization of Agriculture – The decree underscores the need to develop a regulatory framework for land management and protection, as well as to enhance infrastructure for irrigation and agricultural processing. The smart web applications described in the article can be integrated into these processes, enabling automated monitoring and control of land use, which will increase efficiency. Accessible web technologies for farmers will also foster the development of agricultural control systems based on big data.

2. Development of agroparks and promotion of investments in agricultural production – The decree regulates agropark operations and supports enterprises in the agricultural sector. The intelligent systems outlined in the article will assist agropark enterprises and small farms in automating resource management processes, optimizing production, and reducing costs. Applications for analyzing soil and weather data will enable agroparks to allocate resources effectively, plan irrigation, and forecast yields.

3. State support and simplified access to resources – The decree highlights the importance of simplifying access to financial resources for producers and supporting micro, small, and medium enterprises in agriculture. The intelligent web applications proposed can reduce farm control costs and facilitate system adaptation to new conditions. Such solutions will increase productivity and product quality, qualifying producers for state support through tax incentives and credit options.

4. Simplification of export procedures and market development – The decree also addresses measures to simplify the export of agricultural products. Introducing intelligent systems for managing agricultural production and resource use through web applications can enhance product quality and competitiveness in foreign markets, aligning with goals to boost exports and increase the share of the non-oil sector.

To promote the development of web technologies for Azerbaijan's agricultural sector, it is essential to integrate international experience and modern solutions. The future advancement of smart agriculture technologies may include:

- Developing more accurate forecasting models based on local data for various regions of the country.
- Creating predictive analysis systems to prevent climate and environmental risks.
- Establishing online platforms to train farmers in new control methods and the use of agricultural web applications.

By harmonizing cutting-edge technologies [3], [4] with the policy initiatives and infrastructure improvements outlined in national directives Azerbaijan's agriculture sector can accelerate its digital transformation. Farmers, benefiting from web-based platforms and AI-driven analytics, can anticipate climate challenges, optimize water usage, and enhance overall production. These systems also foster resource-efficient operations by integrating robotics, big data, and precision agriculture, thereby reducing costs and environmental impact. As producers gain streamlined access to financial support and simplified export procedures, the foundation is set for a more competitive agro-economy. Ultimately, this synergy ensures sustainable growth, resilient supply chains, and long-term prosperity for Azerbaijan's agriculture.

3. International experience

[5] As shown by global experience, technologies such as cloud computing, the Internet of Things (IoT), big data, and artificial intelligence (AI) have a significant impact on enhancing the efficiency and automation of agricultural production. The implementation of these technologies in countries like Israel, France, China, and Germany has contributed to the continuous and sustainable development of the agricultural sector. International examples, such as agricultural systems in Israel and France, demonstrate how cloud computing and IoT technologies can enable remote control of agricultural processes.

In Azerbaijan, integrating cloud platforms into the agro-industrial sector would allow for centralized management of mechatronic devices, data collection and processing directly from the field, as well as real-time transmission of control commands. These web applications provide seamless monitoring and control of robotic systems, reducing the need for human intervention and enhancing the accuracy of decision-making.

The use of big data and artificial intelligence is an advanced practice that has already been implemented in countries such as China and Germany. Mechatronic devices in agricultural production can collect extensive information on soil conditions, weather, and plant productivity. Web applications utilizing artificial intelligence algorithms enable the analysis of this data and allow for automated decision-making in agricultural process management. In Azerbaijan, this approach could help optimize resource use (such as water and fertilizers) and increase productivity.

[6], [7] As remote control of mechatronic devices requires the exchange of large amounts of data over the Internet, ensuring data security is of great importance. Agricultural web applications adhere to international security standards like ISO/IEC 27001 to protect data. Implementing these standards in Azerbaijan would safeguard farmers and agricultural producers from cyber threats and ensure the smooth operation of all systems.

Thus, leveraging international experience in developing remote control technologies for web applications to manage autonomous mechatronic systems could be a crucial step in modernizing agriculture in Azerbaijan. In addition to enhancing control over agricultural processes, the adoption of these technologies would strengthen the country's export potential, increase the competitiveness of products, and ensure the efficient use of natural resources.

The latest advances in intelligent systems for smart agriculture are discussed. The focus is on the integration of sensors and artificial intelligence to automate processes such as soil monitoring, irrigation controlling and yield forecasting. The authors emphasize the importance of web applications for remote system control and note that existing interfaces require further optimization for simpler and more intuitive user interaction.

[8-11] The article explores the potential of autonomous robotic systems in agriculture, focusing on mechatronic devices used for irrigation, harvesting, and plant health monitoring. It highlights the challenges of integrating such systems on small and medium-sized farms due to high costs and technical complexity. The authors suggest that the development of smart web applications, which can reduce entry barriers, could facilitate the adoption of these solutions. This can be achieved through modular applications with simplified UX/UI designs and the use of wireless technologies to control robots.

The article analyzes IoT-based applications for smart agriculture, emphasizing the connection between sensors and web applications. It explores how smart systems can utilize sensor data to improve resource management, particularly water. A key focus is the need for flexible web applications that allow farmers to manage all aspects of their farm remotely from a single interface. Additionally, the paper highlights the importance of integrating fuzzy logic for decision-making under uncertainty, especially in the context of changing climate conditions.

The paper reviews existing robotic solutions for sustainable agriculture and argues that autonomous robots can significantly reduce water and resource usage, improve irrigation control, and address labor shortages. However, it identifies a major issue: the lack of user-friendly web applications for managing these systems, which limits their appeal among farmers. The paper calls for the development of intuitive interfaces that make it easy for users with low technical skills to create and manage robots.

An analysis of these scientific publications reveals that current research is focused on developing flexible and intuitive web applications for autonomous systems that can address resource management, respond to climate change, and optimize agricultural operations.

1. Analysis of the main functional components of smart web technology and the design process

Based on the analyzes conducted before determining the main components of smart web technology, its development directions are defined as shown in figure 1.

As shown in the figure, human-computer interaction (HCI) is considered one of the key components for ensuring the sustainable development of smart web technologies in agriculture. The UX/UI design of these technologies enables several important advantages. First, it allows the creation of intuitive, user-friendly interfaces that even non-technical farmers can navigate easily. Visual elements should be clear and informative, allowing for quick system configuration and real-time monitoring of fields and equipment. For instance, dashboards that display key metrics–such as moisture levels and soil conditions–should be readily accessible and visually straightforward.

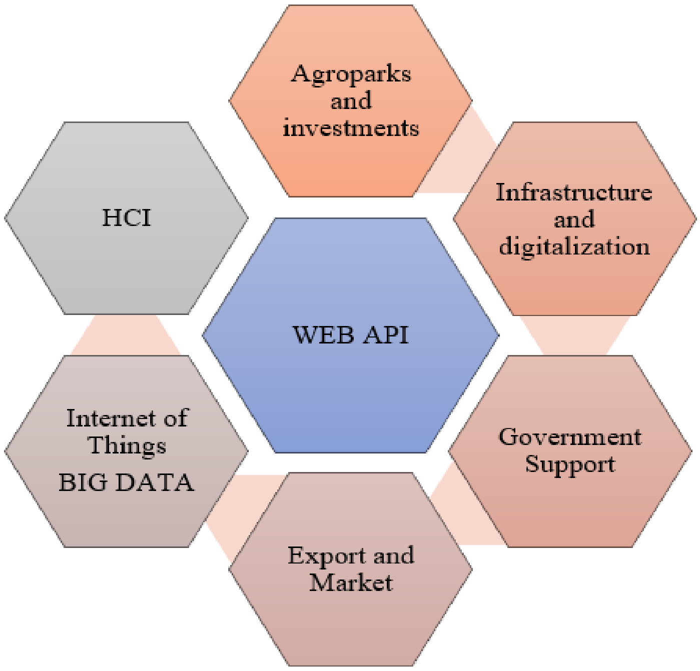

Figure 1 – Development directions of smart web technologies

Moreover, the mobility and adaptability of these interfaces allow farmers to manage production processes from anywhere, ensuring flawless display across different devices and screen sizes, and accommodating lower internet speeds commonly found in rural areas. The interface should also incorporate controls like voice commands or simplified data-entry forms to facilitate ease of use.

Seamless integration with IoT and AI technologies is another essential aspect, enabling easy access to data collected by IoT devices and offering farmers data-driven solutions based on intelligent analysis. Interfaces should provide accessible tools for creating automated processes and generating recommendations based on big data and predictive models. Leading companies such as John Deere and Trimble, for example, offer IoT-based precision farming solutions that illustrate the benefits of designing IoT interfaces for agricultural applications.

Finally, smart web applications must be adaptable to the unique agricultural conditions of each country or region, such as variations in soil, climate, and crop types. Flexible interfaces allow users to adjust the system to their specific environment, with features like precision farming algorithms, automated irrigation, and resource management driven by local weather data. Cloud-based services, including Google Cloud for Agriculture and Microsoft Azure, support such adaptability by offering tools for data analysis, sensor data collection, and yield forecasting.

As a result of the analyses conducted, an IoT-based monitoring system schematic with a UX/UI-designed mobile app has been proposed, as shown in Figure 2.

As shown in the figure, the diagram illustrates the operational principle of an intelligent control and monitoring system for agriculture. The system starts with a power supply, which passes through a rectifier to convert AC to DC, and then to a PID (Proportional-Integral-Derivative) regulator. The PID regulator ensures the stability of the system's control elements, and the control results are displayed on the screen and control panel. The main system consists of robotic devices that receive data from various sensors. Temperature, water level, and soil moisture sensors are connected to the robot devices, each transmitting its parameters to enable monitoring of soil and environmental conditions. Based on this data, the robotic devices perform specific actions. For instance, the DC fan provides ventilation, the DC motor handles mechanical functions, and the water pump regulates the irrigation system. The system is equipped with a GSM module, which allows remote data transmission over mobile networks. This enables control of the system via a UX/UI interface on a mobile app. Additionally, the system connects to an IoT (Internet of Things) platform through a Wi-Fi module. The IoT platform sends the system's data to a cloud platform, where it is stored in an external database.The UX/UI design is crucial for this system, as it provides users–especially farmers without technical knowledge–with an easy and intuitive interface. This design allows farmers to monitor device status and key field parameters in real-time and to adjust the system as needed. The mobile app's design ensures optimal display on different screen sizes and high adaptability, even under low internet connectivity conditions.

Showcasing the advantages of the proposed IoT-based monitoring system over other traditional and IoT systems (table 1).

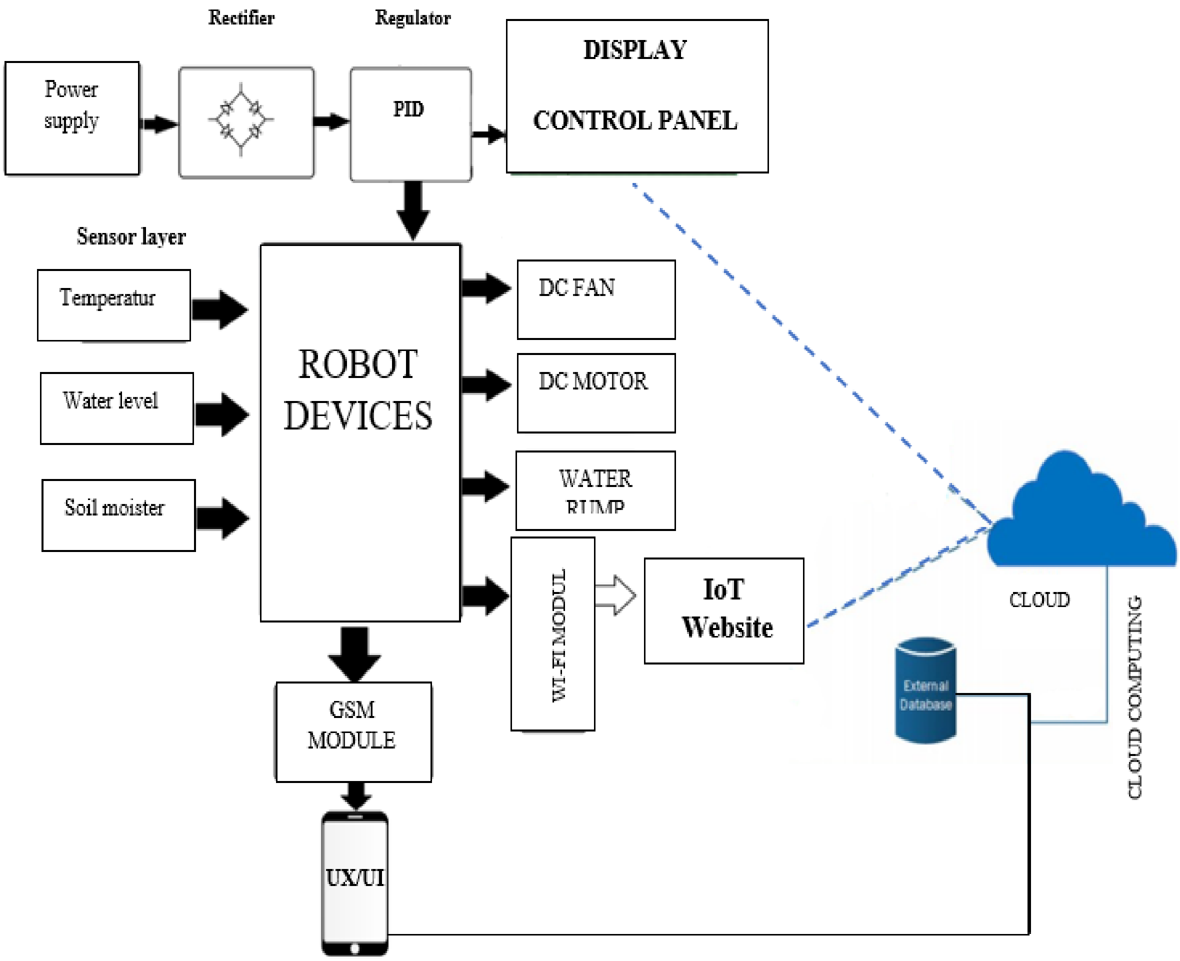

Figure 2 – Solutions based on the Internet of Things

Table 1 – IoT-based monitoring system

Feature/Advantage	Proposed IoT System	Traditional Agricultural Monitoring System	Other IoT Systems
Automation and Control Precision	PID controller ensures precise, stable control based on sensor data for automatic actions.	Manually controlled or simple automatic systems with less precision.	Automated, but may involve complex algorithms that require more configuration.
Real-Time Monitoring	Real-time monitoring through sensors with data accessible via mobile app for control.	Data is collected at specific intervals, not in real-time.	Real-time monitoring available, but app usability is often limited.

Continuation of the table

Feature/Advantage	Proposed IoT System	Traditional Agricultural Monitoring System	Other IoT Systems
Remote Control	GSM and Wi-Fi modules enable remote control and data transmission.	Manual intervention or local control; no remote control.	Remote control available, but connection reliability may be limited.
User-Friendly Mobile App	Intuitive UX/UI design with a simple and accessible mobile app interface.	Not user-friendly, requires technical knowledge.	User-friendly interfaces exist but may require more technical knowledge.
Internet and Mobile Network Connectivity	Works even with low internet connectivity, designed for minimal network use.	Dependent on stable internet connection, does not work in low connectivity areas.	Requires internet connection, performance may drop in poor connectivity.
Energy Efficiency	Energy-efficient components (DC motors, fans, etc.) ensure lower energy consumption.	Higher energy consumption or dependency on energy sources.	Some IoT systems focus on energy savings, but energy consumption may still be high in certain setups.
Cloud and IoT Platform Integration	Data stored and analyzed in the cloud, integrated with an IoT platform.	Data stored locally, no remote analysis possible.	IoT and cloud integration present, but data processing might be limited in some systems.
User Training and Accessibility	Easy to use for agricultural workers with minimal training required.	Requires technical knowledge and more complex management.	Some systems require user training, but most are designed for simplicity.

This comparative table highlights the significant advantages of the proposed IoT-based monitoring system in terms of real-time monitoring, remote control, user-friendly design, and energy efficiency compared to traditional systems and other IoT-based solutions. Traditional systems often require technical expertise and are more dependent on stable internet connectivity, while the proposed system offers more flexibility and ease of use.

Below is the process for the design mechanism of the proposed mobile app UX/UI, broken down into stages as described in Table 2.

Table 2 – Design mechanism of the proposed mobile app UX/UI

Stage	Description
User Needs Analysis	Understanding the needs of target users, such as agricultural workers. Surveys and research are conducted to analyze daily tasks and the level of technical skills of the users.
Prototype Development	Creation of simple sketches and initial design templates. The core layout of the proposed user interface is defined.
Interface Design	Designing the mobile app with an intuitive, easy-to-understand interface for the user. Elements like icons, indicators, and graphs should be simple and clear.
Mobile App Prototype Testing	Initial design is tested by the target users. Feedback is gathered to refine and improve the design based on user input.
Functionality Enhancement	Improving the app's functionality based on user feedback. Simple data entry forms, voice commands, and interactive elements are added to enhance user interaction.
Mobile App Testing and User Feedback	All features of the app are tested, and feedback from users is collected. Final adjustments are made to the design and functionality based on test results.
Deployment and User Training	The mobile app is launched, and training materials are provided to users. Users are educated on the full features and how to use the app effectively.
Support and Updates	Continuous monitoring of the mobile app, providing support based on user complaints, and implementing regular updates to improve functionality.

This table outlines the stages of developing the UX/UI design for the proposed mobile app. At each stage, user needs and feedback are prioritized to improve the app's design and functionality, ensuring an optimized user experience.

4.1. Development and analysis of the functional diagram of a smart web application.

[12-15] Preparation and analysis of the functional diagram of a smart web application at the design stage is the main stage of creating a system for controlling agricultural processes using modern technologies. The functional diagram serves as a tool for visualizing and structuring all components and stages of interaction of the system, allowing for the effective integration of data, IoT devices, automation mechanisms and user interfaces (Fig. 3).

As can be seen from the figure, the main components required for the web application to work include:

1. Users – farmers, agricultural technologists, engineers who will use the web application to control processes such as irrigation, soil analysis, yield forecasting.

2. Mechatronic devices and sensors (IoT) – devices that collect data from the fields (sensors for humidity, temperature, soil condition) and interact with the system to perform tasks (e.g. controller, motor, robot, etc.).

3. Centralized server and cloud platforms – where data is stored, processed, collected, analyzed and decisions are made.

4. Data analysis system. This component uses artificial intelligence algorithms and fuzzy logic to analyze data from sensors and optimize control processes. This system allows you to adapt to changing conditions, such as changes in weather or soil condition.

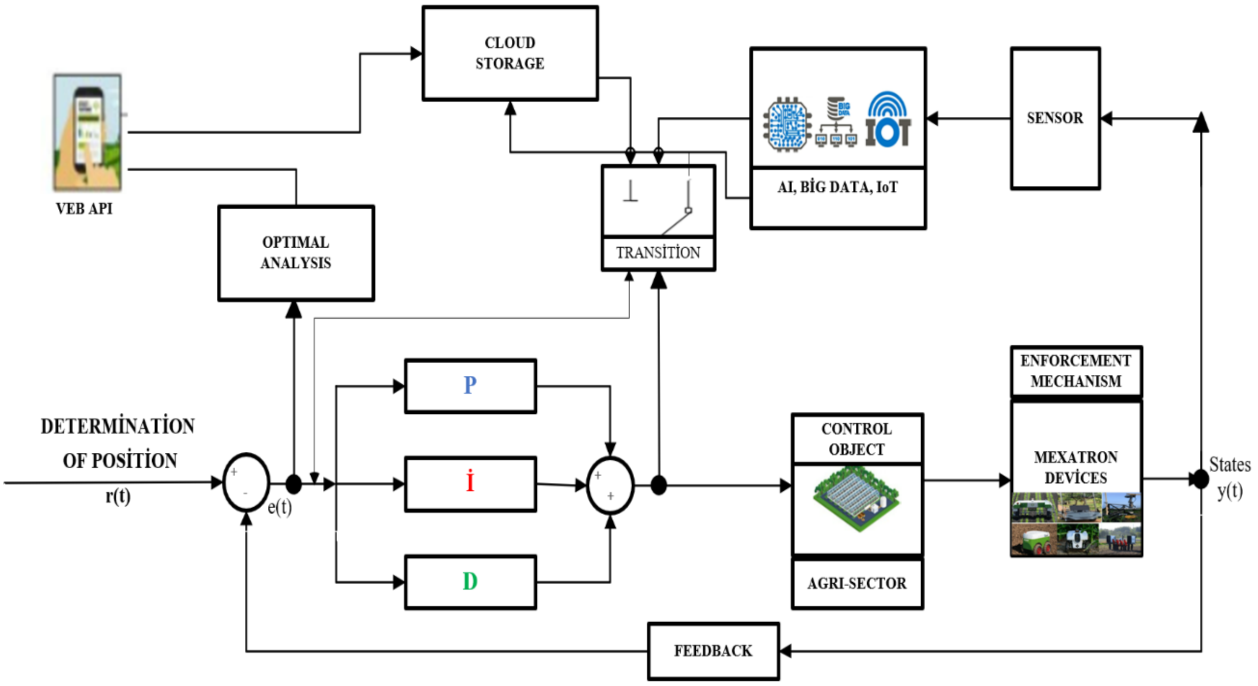

Figure 3 – Functional diagram of an intelligent web application

The basic functional diagram of the proposed methodology for developing intelligent web applications for autonomous control of robotic devices in the agricultural industry is a multi-level system in which the main components interact to ensure efficient and coordinated control of agricultural processes. At the first level, robotic devices with built-in sensors are deployed in agricultural fields to measure key parameters such as humidity, temperature, soil condition, illumination and other environmental factors. The sensors transmit the collected data to the central server via wireless channels (Bluetooth, Wi-Fi). All received data is transmitted to the cloud infrastructure for storage and processing. The cloud platform performs several tasks: data collection, filtering and running artificial intelligence-based analysis algorithms. It uses machine learning and fuzzy logic models to assess current field conditions, predict future conditions (e.g. weather changes) and optimize control decisions. At the next stage, the processed data is used by the artificial intelligence system to generate recommendations or direct commands for controlling robots. Based on the data received and using fuzzy logic algorithms, the system makes decisions about, for example, when and how best to water a field, how much water to use, or what resources to allocate for processing a particular field.

This process can be automatic or partially user-assisted. To control the system, farmers or operators use a web application with an intuitive interface, through which they can monitor ongoing processes, monitor the work of the robots in real time, and receive notifications about current indicators and changes in the environment. The web application is adapted for use on both desktop computers and mobile devices, which allows the system to be controlled from anywhere in the world. If necessary, the user can send control commands to the robots via the web application, for example, adjusting irrigation modes or changing the operating parameters of the robots. Commands are transmitted back to the devices via Bluetooth or Wi-Fi, where they are executed in real time. In addition, robots can interact with each other to coordinate their actions, for example, jointly performing watering or harvesting tasks to increase overall productivity.

An important part of the scheme is the coordination of the actions of several robots, which allows for more efficient task execution. Collaboration is carried out centrally using a cloud platform and an intelligent system that distributes tasks between robots, minimizing overlap and duplication of efforts. This enables automation of more complex processes, such as the processing of large agricultural fields, with minimal resource input. This functional design includes full integration of sensor data, cloud technology, artificial intelligence, and a user-friendly control interface that provides high adaptability and efficiency in the face of changing environmental factors and agricultural challenges. Thus, based on the obtained analysis, a visual diagram of the smart web application is depicted in Figure 4.

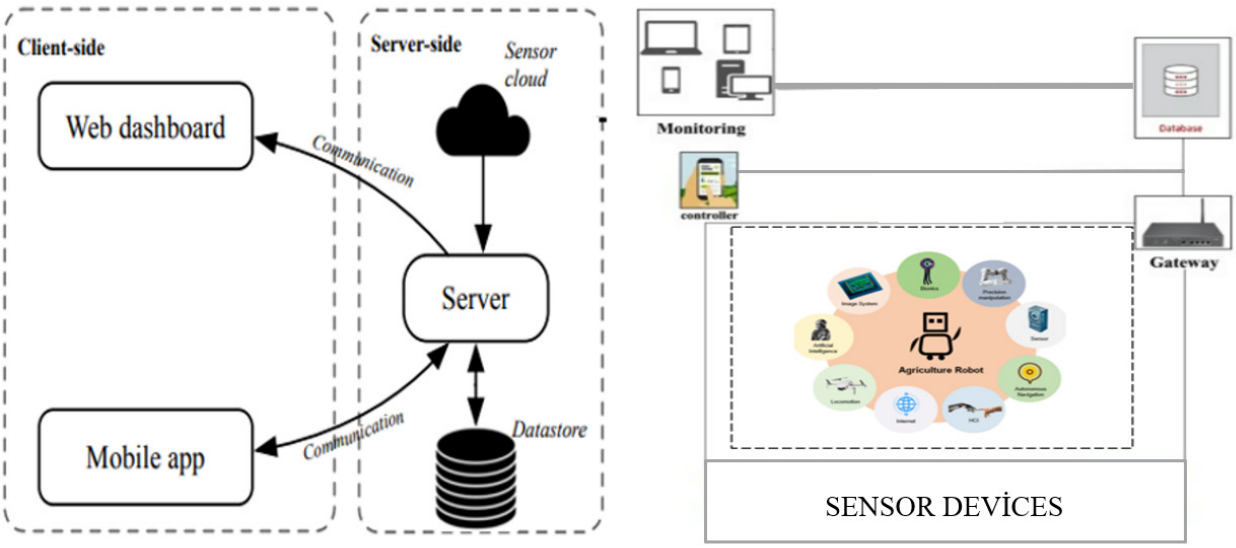

Figure 4 – Smart web application visual activity scheme

4. Conclusions

A smart web application for the agricultural sector plays a key role in automating agricultural process control, and its success largely depends on a well-thought-out UX/UI design. An intuitive interface helps farmers effectively interact with the system, even if they lack technical skills. The importance of UX/UI is that the visuals should be clear and easy to interpret, allowing the user to make prompt decisions based on information that reflects the current state of the industry. The functional design of the application, including collecting data from IoT devices, processing it on a cloud platform and providing recommendations, makes agricultural process controlling more accurate and convenient. The proposed work scheme also facilitates control of all stages of work: from field monitoring to mechatronic control. Thus, a successful design and well-thought-out structure of the application create conditions for continuous productivity improvement and resource optimization in the agricultural industry.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. President of the Republic of Azerbaijan, "Decree of the President of the Republic of Azerbaijan on a number of measures on the development of production and processing industry in the agricultural sector," 2021. [Online]. Available: https://president.az/az/articles/view/52463
2. V. Karimli, "Investigating, implementing and studying ways to improve economic management mechanisms in the agrarian field." [Online]. Available: https://www.geostrategiya.az/news.php?id=125
3. Akshay Prashanth Shet and P. Shekar, 'Artificial Intelligence And Robotics In The Field Of Agriculture', 2020, doi: 10.13140/RG.2.2.10162.84167.
4. A. Bechar and C. Vigneault, 'Agricultural robots for field operations: Concepts and components', *Biosyst. Eng.*, vol. 149, pp. 94–111, Sep. 2016, doi: 10.1016/j.biosystemseng.2016.06.014.
5. R. Gómez-Chabla, K. Real-Avilés, C. Morán, P. Grijalva, and T. Recalde, 'IoT Applications in Agriculture: A Systematic Literature Review', in *ICT for Agriculture and Environment*, R. Valencia-García, G. Alcaraz-Mármol, J. del Cioppo-Morstadt, N. Vera-Lucio, and M. Bucaram-Leverone, Eds., Cham: Springer International Publishing, 2019, pp. 68–76. doi: 10.1007/978-3-030-10728-4_8.
6. Md. N. Mowla, N. Mowla, A. F. M. S. Shah, K. M. Rabie, and T. Shongwe, 'Internet of Things and Wireless Sensor Networks for Smart Agriculture Applications: A Survey', *IEEE Access*, vol. 11, pp. 145813–145852, 2023, doi: 10.1109/ACCESS.2023.3346299.
7. R. C. D. Oliveira and R. D. D. S. E. Silva, 'Artificial Intelligence in Agriculture: Benefits, Challenges, and Trends', *Appl. Sci.*, vol. 13, no. 13, p. 7405, Jun. 2023, doi: 10.3390/app13137405.
8. G. Durga Sai Prasad, A. Vanathi, and B. S. Kiruthika Devi, 'A Review on IoT Applications in Smart Agriculture', in *Advances in Transdisciplinary Engineering*, K. Ramachandra Murthy, S. Kumar, and M. Kumar Singh, Eds., IOS Press, 2023. doi: 10.3233/ATDE221332.
9. M. H. Widianto and B. Juarto, 'Smart Farming Using Robots in IoT to Increase Agriculture Yields: A Systematic Literature Review', *J. Robot. Control JRC*, vol. 4, no. 3, pp. 330–341, May 2023, doi: 10.18196/jrc.v4i3.18368.
10. M. Dhanaraju, P. Chenniappan, K. Ramalingam, S. Pazhanivelan, and R. Kaliaperumal, "Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture," Agriculture, vol. 12, no. 10, Art. no. 10, Oct. 2022, doi: 10.3390/agriculture12101745.
11. A. Pawar and S. B. Deosarkar, "IoT-based smart agriculture: an exhaustive study," *Wireless Netw*, vol. 29, no. 6, pp. 2457–2470, Aug. 2023, doi: 10.1007/s11276-023-03315-7.
12. A. M. Mustafayeva and G. S. Bakhshiyeva, 'An innovative approach in the study of mechatronic devices', *Inform. Control Probl.*, no. 1(3), pp. 39–45, May 2022, doi: 10.54381/icp.2022.1.06.
13. A. Mustafayeva, E. Israfilova, E. Aliyev, E. Khalilov, and G. Baxshiyeva, 'ANALYSIS BASED ON UX DESIGN OF MOBILE PLATFORMS APPLIED IN AGRICULTURAL SECTORS', 2023.
14. A. Mustafayeva and E. Aliyev, "Trends in the application of robotic devices in agricultural sectors," in *Materials of the International Scientific Conference on "Development Prospects of Innovative Technologies in the Agricultural Sector"*, Lankaran, Azerbaijan, Dec. 23, 2022, pp. 139–141. [Online]. Available: https://lsu.edu.az/new/imgg/Konfrans%20material%C4%B1%20-%2023.12.2022.pdf
15. A. M. Mustafayeva, G. S. Bakshiyeva, E. N. İsrafilova, E. M. Əliyev, and E. O. Xəlilov, "Opportunities and prospects for the application of intelligent robotic devices in the agricultural sector," in *Engineering Cyber-Physical Systems and Critical Infrastructures: Proceedings of the 4th International Conference on Artificial Intelligence and Applied Mathematics in Engineering (ICAIAME 2022)*, Springer Nature Switzerland AG, 2023. [Online]. Available: https://trebuchet.public.springernature.app/get_content/eea2d479-81c8-44ff-82ba-3748a1b11c39

Information About Author

Aida Mustafayeva is a Head of the Department of Information Technologies at Mingachevir State University (Mingachevir, Azerbaijan, aida.mustafayeva@mdu.edu.az). Her research interests focus on the development of intelligent web applications and autonomous control systems for robotic devices, particularly in the agricultural sector, emphasizing UX/UI design, IoT integration, and data-driven optimization. ORCID ID: 0000-0003-0801-5605.