A Design of Intelligent Ecological Multifunctional Plant and Animal Breeding System

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Abstract

The intelligent ecological multi-functional system for animal and plant cultivation integrates PLC programmable controllers and microcontroller-based automatic control technology. This innovative approach amalgamates aquaculture with horticulture, fostering a symbiotic environment for the breeding of animals and plants. The system's operations are categorized into four key components: mechanical structure, environmental perception, automatic control, and intelligent networking. Its comprehensive functionality encompasses plant monitoring, self-checking of temperature and humidity, group control for fertilizer replenishment, consistent temperature regulation, full-spectrum illumination, advanced filtration, fogging supplementation, versatile water management, fertilizer blending, and water purification through sterilization.

Keywords: Intelligent Ecology, PLC programmable controller, Environmental sensing, Eco-agriculture, microcontroller, monitoring

1. Introduction

With the rapid development of science and technology, intelligent technology has emerged in the field of agriculture. Based on Siemens S7-1200 version PLC programmable controller and AT89C51 microcontroller automatic control technology [1]. this thesis aims to integrate aquaculture and horticulture planting, and innovatively realize plant and animal symbiotic aquaculture. The most important feature of the system is that it can realize ecological energy saving, environmental protection recycling and symbiotic breeding of plants and animals, which pushes the intelligent ecological breeding to a new height.

The work is mainly composed of four modules: mechanical structure, environmental sensing, automatic control and intelligent networking. System functions include plant monitoring, temperature and humidity self-checking, group control and fertilizer renewal, constant temperature and heating, full illumination, multiple filtration, fogging supplementation, multi-purpose water, fertilizer mixing and sterilization of water purification and other special functions [2]. In addition, the system introduces an animal feeding system, which includes an adaptive feeding cabin and an intelligent feeding system that monitors the physiological parameters of the animals and automatically feeds them at regular intervals and quantities in order to realize intelligent feeding management.

The rest of this paper is organized as follows. The second part introduces the top ten functional designs. The third part introduces the working principle of the intelligent ecological multifunctional plant and animal breeding system. The fourth part is hardware design, including mechanical structure part design, environment sensing part design, automatic control part design and intelligent networking part design. The fifth part is the software design. The sixth part summarizes the main content of this paper.

2. Ten functional designs

Intelligent ecological multi-functional animal and plant breeding system aims to realize fully automatic group control of plants and aquatic animals, which contains ten key functions such as plant monitoring, temperature and humidity self-checking, group control and fertilizer renewal, constant temperature and heating, full illumination and light supplementation, multiple filtration, and fogging supplementation. The application of these technologies not only significantly reduces manual intervention and improves breeding efficiency and production, but also promotes the recycling of resources and realizes environmentally sustainable production.

This intelligent ecological multi-functional plant and animal breeding system realizes all-round monitoring and management of plants and animals by integrating advanced monitoring and control technologies,

minimizing manual operations and thus improving overall breeding efficiency and production. The top ten functional diagrams of the system are shown in Fig. 1.

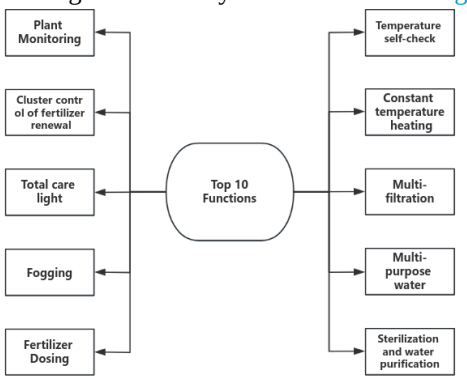

Fig. 1 The top ten functional diagrams of the system

2.1. Aquaponics Technology Design

Based on the concept of energy recycling, the system is guided by the concept of watering vegetables with fish water and improving the growth environment of fish with vegetables, integrating aquaculture and hydroponic cultivation technologies to build a harmonious aquaponics system. In urban family application, this technology can reduce the purchase expenditure of vegetables and fishery products and create a green and energy-saving family living environment.

2.2. Temperature parameter change automatic judgment sliding table contraction design

The system monitors the ambient temperature through an RS485 industrial-grade temperature and humidity transmitter to ensure that the slide table is intelligently triggered to retract automatically in adverse climatic conditions (less than 15 degrees Celsius or more than 30 degrees Celsius) to prevent plants from being damaged by cold or overheating. Meanwhile, through intelligent determination of the current time, the system realizes artificial light supplementation at 18:00 pm to ensure that plants can still obtain sufficient light when it is dark, while it automatically extends at 8:00 am to absorb sunlight to provide a good growing environment for plants. Such time determination and intelligent regulation mechanism effectively guarantees the growth needs of plants in different time periods.

2.3. Plant group control automatic humidification design

The system is equipped with a humidity sensor to monitor the humidity of the plant growth environment in real time. When the humidity is lower than 80%, the intelligent system automatically triggers the humidification device to ensure that the photosynthesis, respiration and transpiration of plants proceed normally. Through time triggering and intelligent determination of air humidity at 8 a.m., 11 p.m. and 5 p.m., the system decides whether or not to humidify to meet the humidity needs of the plants at different times of the day, thus providing a suitable growing environment [3]. This intelligent humidification system helps to maintain the physiological activities of plants and improve the breeding efficiency.

2.4. Plant group control automatic fertilization design

The system performs real-time sensing and calculation through sensors at the height of the plants, and judges the reasonable amount of fertilizer (CM/MG) according to the growth status of the plants. In terms of time triggering, the system intelligently sets 3:00 pm to 10:00 pm every day as the fertilizer application time period to ensure that the plants get the right amount of nutrients during this time period. In addition, soil sensors are used to monitor the levels of nitrogen, phosphorus, potassium and other fertilizers in the soil. The system intelligently determines the soil condition according to the plant species and the seasons, and applies the right amount of fertilizer when needed. Such an intelligent fertilizer application mechanism is designed to ensure that plants are supplied with appropriate nutrients, thereby improving breeding efficiency and yield.

2.5. Plant group control automatic watering design

The system decides whether watering is needed by checking whether the soil moisture reaches the set value through real-time soil moisture monitoring every 10 minutes. In addition, the system intelligently takes into account plant species and seasonal changes, and based on these factors determines whether watering is required for the day, ensuring that soil moisture meets the plant's growth needs. This integrated intelligent watering mechanism aims to provide plants with the right amount of water according to the actual situation, ensuring that they receive appropriate irrigation in different seasons and growth stages, and improving breeding efficiency.

2.6. Plant group control automatic nutrient replenishment design

The system intelligently calculates the corresponding levels of nutrients such as nitrogen, phosphorus and potassium (CM/MG) through plant height sensing. In terms of time triggering, the system is set to automatically replenish nutrients once a month to improve plant resilience and resistance and activate microbial vitality in the soil [4]. This integrated highly sensible and automatic replenishment mechanism helps to

ensure that plants are supplied with appropriate nutrients at different growth stages, improving their resilience and thus enhancing the ecological balance of the whole aquaculture system.

2.7. Automatic Oxygen Supply Design for Aquatic Animals

According to the change of water temperature, automatic oxygen supply is realized to ensure the oxygen demand of fish in different temperature ranges.

2.8. Automatic sterilization design

The system adopts the principle of ozone sterilization, through which ozone acts on the cell membrane of microorganisms, leading to cell death, so as to achieve the purpose of sterilization, anti-inflammation and detoxification. In addition, the system also applies UV germicidal lamps, which utilize UV rays to destroy the DNA or RNA molecular structure in the cells of various microorganisms in the water, effectively killing various pathogens in the water in order to keep the water quality clean. This integrated sterilization system is designed to ensure the hygienic condition of aquaculture water, improve water quality, and guarantee the healthy growth of plants and animals.

2.9. Solar photovoltaic power generation system design

The system is centered on PLC and HMI, and is powered by electricity from the solar photovoltaic power generation system reserve. According to the light condition, the system realizes automatic switching of power supply to ensure the normal operation of the equipment under different light conditions. In addition, the system intelligently utilizes LED plant growth lights for automatic replenishment. When natural light is insufficient, the solar PV system activates the LED plant growth lights to provide an additional light source to promote plant growth. This integrated PLC and solar photovoltaic power generation system, as well as the automatic replenishment function of the LED plant growth lamps, effectively guarantees the sustainable operation of the system and the growth needs of plants under different light conditions.

2.10. Design of LED Plant Grow Lights for Yield Improvement

Spectral regulation is crucial to plant growth, and red light promotes chlorophyll formation and carbohydrate synthesis, fuels the growth of long sunlight plants, delays the growth of short sunlight plants, and promotes seed germination. Theoretical and experimental evidence shows that red light has the strongest photosynthetic effect, and the use of red-rich light sources for supplemental lighting can advance plant flowering and fruiting and promote organ formation. Blue light helps stomata open, promotes the entry of external carbon dioxide, increases the rate of photosynthesis, and is conducive to protein synthesis. Blue light accelerates the growth of short-daylight plants, slows down the growth of long-daylight plants, and promotes leaf growth. Artificial supplemental light using a blue light-rich light source can delay flowering and allow full plant growth [5].

Plant grow lights are electric light sources designed to stimulate plant growth by emitting electromagnetic waves suitable for photosynthesis, and are used in applications where natural light is not available or where additional supplemental light is required. In winter, when daylight hours are insufficient to meet the needs of plants, plant lights are used to extend light hours and prevent plants from growing unduly. Meanwhile, the plant curtain green light realizes cooling effect in summer by blocking heat, shading strong sunlight and providing a cool indoor environment; in winter, it prevents cold air from intruding and provides thermal insulation. The ambient light is used to provide extra light, highlight the color of the fish, and meet the fish's need for light. In the absence of sunlight, the ambient light creates a comfortable environment for the fish tank, creating a more perfect viewing effect. The finished rendering and exterior design are shown in Fig. 2.

Fig. 2 The finished rendering and exterior design

3. Working Principle

Firstly, the ornamental and convenient management of plants is realized through the design of plant sliding table. The plant sliding table can display the plants in the balcony or outdoor community, and when the environment changes, the plants can be cooled, humidified, and replenished with light through PLC control in order to reduce the labor cost and improve the breeding efficiency. The plant curtains are driven by 24V motor for 90 degree opening and closing. Secondly, the system supports hydroponic plant cultivation, which can save space utilization by putting the plant curtains away. The root system of hydroponic plants can filter the fish tank water flowing through the plant curtains, realizing the recycling of aquaponics resources. Finally, the system

is equipped with an industrial control touch screen to realize real-time feedback on the monitoring of plants and animals and human-computer interaction.

For automatic sensor detection, ultrasonic ranging, soil sensors, environmental sensors, PLC time calculation and other multiple logic judgments are used to improve the accuracy of plant control and help improve the survival rate of plants. Fertilizer pump adopts peristaltic pump, and through the "one drop one number" control method, it realizes the precision of fertilizer application and avoids the situation of using too much or too little fertilizer. In the filtration system, through a variety of filtration methods, such as hydroponic plant stalks, UV lamps, ozone and active filters, etc., the depth of the fish tank water poisoning and filtration, to achieve the healthy operation of the aquaponics system. The working schematic is shown in Fig. 3.

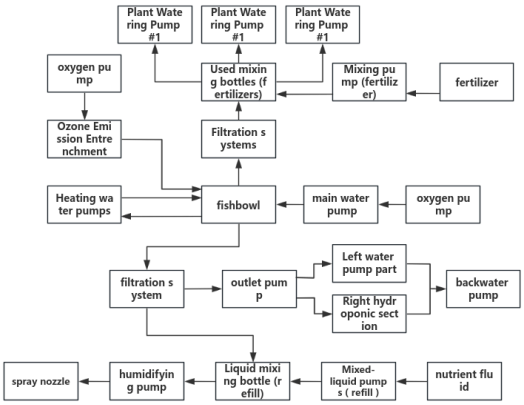

Fig. 3 The working schematic

4. Hardware Design

The overall structure of the intelligent ecological multifunctional plant and animal breeding system is divided into the following four major components. The overall structure is shown in Fig. 4.

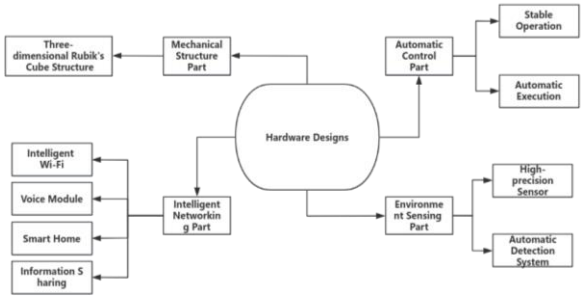

Fig. 4 The overall structure

4.1. Mechanical structure design

The three-dimensional Rubik's Cube structure is adopted, which is inspired by the aerospace station. The three-dimensional Rubik's Cube structure is characterized by a large available space, which is divided into five different unfolding surfaces, with different functions corresponding to different surfaces, which are specifically divided into the "display and observation surface", "aquatic planting surface", "photovoltaic surface" and "energy collection surface" [6]. The different surfaces have different functions, specifically divided into "display and observation surface", "water planting surface", "photovoltaic surface", "energy collection surface", "sliding platform structure surface" and "control and manipulation surface".The mechanical structure is shown in Fig. 5.

Fig. 5 The mechanical structure

4.2. Environment Sensing Part Design

Composed of various high-precision sensors, the environment sensing part is equivalent to the "eyes" and "ears" of the intelligent ecological multi-functional

animal and plant breeding system, which can automatically detect the working state of the system and convert various process parameters such as temperature, humidity, flow rate, liquid level and composition into uniform standard signals. Physical quantities such as temperature, humidity, flow, liquid level, composition, etc. are transformed into uniform standard signals to meet the requirements of information transmission, processing, storage, display, recording and control, etc. It is the first link to realize automatic detection and automatic control. The high precision sensor map is shown in Fig. 6.

Fig. 6 The high precision sensor map

4.3. Automatic control part design

The system is mainly composed of four parts: controller, sensor, actuator and transmitter. The controller is the core

of the system, responsible for automated control tasks without direct human intervention. Through a type of work, a state or a parameter in a machine, equipment or production process, it operates automatically according to pre-set rules. Electricity or other energy sources are used and converted into drive action by means of motors or other devices [7]. Sensors are responsible for detecting process parameters and transmitting the measured values in the form of specific signals for display and regulation. The role of the sensors is to convert various process parameters, such as temperature, flow rate, composition and other physical quantities, into uniform standardized signals, which are then transmitted to the regulator and touch screen for regulation, indication and recording. Such an automatic control system ensures the continuity of the production process and stabilizes the system operation. The controller and controlled object diagram is shown in Fig.7.

Fig. 7 The controller and controlled object diagram

4.4. Intelligent networking part design

As the communication hub of the intelligent ecological multi-functional animal and plant breeding system, the intelligent Wi-Fi module plays an important role in connecting with the outside world, including the close connection with other intelligent devices. As the core component of the smart home LAN, the module is able to independently complete a variety of functions of the home internal network without the intervention of other devices. It converts and shares information between communication protocols, realizing efficient data exchange between networks. Meanwhile, the data exchange function between the smart Wi-Fi module and the external communication network enables the smooth realization of intelligent functions such as remote control, scene control, linkage control and timing control. The design ensures an efficient and seamless connection between the smart farming system and external devices and networks, further enhancing the intelligence of the whole system [8]. The smart Wi-Fi module diagram is shown in Fig. 8.

Fig. 8 The smart Wi-Fi module diagram

5. Software Design

5.1. System logic circuit diagramEnvironment Sensing Part Design

The software system of the Intelligent Ecological Multifunctional Animal and Plant Breeding System is the "brain" of the system, which is responsible for monitoring, controlling and coordinating various components to realize efficient animal and plant breeding. The system logic circuit diagram is a graphical representation of the internal logic structure of the software system, showing the relationship and information flow between different modules. The system logic circuit diagram is shown in Fig. 9.

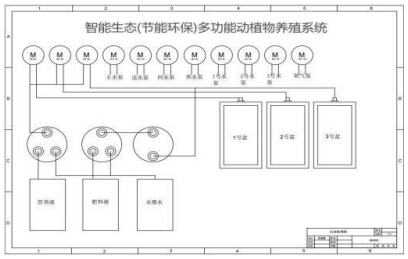

Fig. 9 The system logic circuit diagram

5.2. Human-computer interaction diagrams

The human-computer interaction diagram of the software system of the intelligent ecological multifunctional animal and plant breeding system is the part of the system that interacts with the user directly, providing the user with a friendly operation experience through an intuitive graphical interface. The human-computer interaction diagram is shown in Fig. 10.

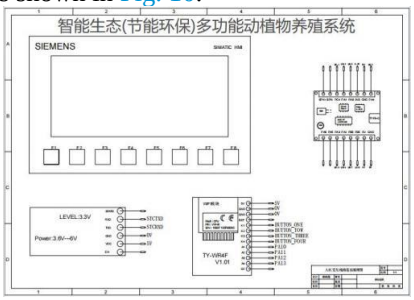

Fig. 10 The human-computer interaction diagram

5.3. Relay and Communication

The relay and communication diagram of Intelligent Ecological Multifunctional Animal and Plant Breeding System software system includes PLC, sensors, relay module, communication module, network connection, data transmission protocol, remote monitoring equipment, etc. PLC realizes equipment control through relay module, sensors monitor environmental parameters, and communication module realizes equipment data transmission and remote monitoring [9]. The relay and communication communication diagram is shown in Fig. 11.

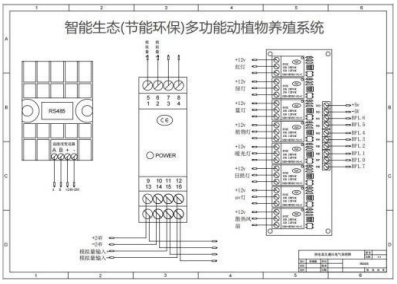

Fig. 11 The relay and communication communication diagram

5.4. Aquaculture System Logic Diagram

In the software system of Intelligent Ecological Multifunctional Animal and Plant Farming System, the logic diagram of aquaculture system is mainly related to the monitoring, control and optimization of aquatic ecology. The logic diagram of the aquaculture system is shown in Fig. 12.

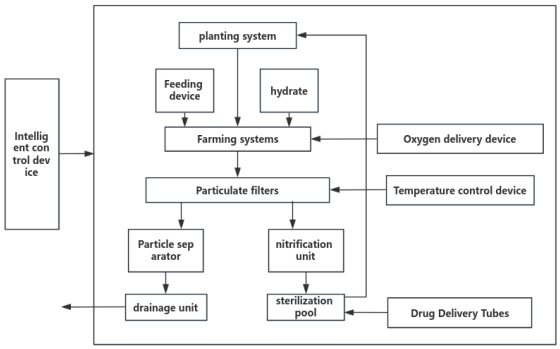

Fig. 12 The logic diagram of the aquaculture system

5.5. Human-computer exchange design

Our system integrates advanced technologies and provides five control modes such as touch, WIFI, voice, Bluetooth, and physical buttons, which provide users with more convenient means of controlling and managing animal and plant breeding. At the same time, the system also introduces intelligent self-learning function, which can automatically update the best planting plan to improve the breeding efficiency and realize the effective use of resources.

5.5.1. Main Picture

The main drawing is shown in Fig. 13.

Fig. 13 The main drawing

(1) Manual mode screen selection
(2) Automatic mode screen selection
(3) Data monitoring screen selection
(4) Running status screen selection
(5) Plant weekly record screen selection
(6) Plant status screen selection

5.5.2. Manual Mode

The manual mode diagram is shown in Fig. 14.

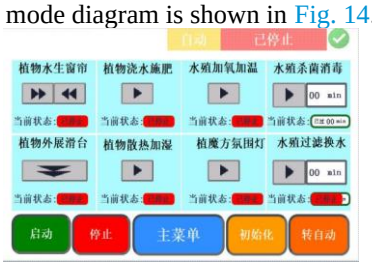

Fig. 14 The manual mode diagram

The system status is divided into running and stopped, and the water colonization system performs sterilization and water filtration every 15 minutes. At the same time, the plant aquatic curtains and outreach sliding table has five states: not in motion (stopped), retracted (being retracted), retracted to complete, stretching out (being stretched out), stretched out to complete. The logic of such states is clear and helps the user to understand the system operation status in real time.

5.5.3. Automatic Mode

The automatic mode diagram is shown in Fig. 15.

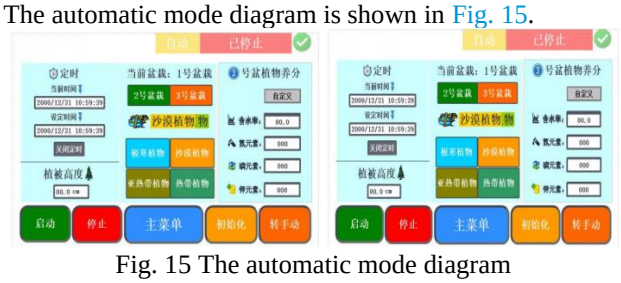

Fig. 15 The automatic mode diagram

When the system is running, the user can set the running time of the automatic mode through the timer function to ensure that the system automatically performs the breeding tasks according to the preset plan within a specific time period. At the same time, the system monitors the growth of the plants in real time and ensures that the necessary breeding operations, such as fertilization and watering, are carried out at the right time through the real-time feedback of the plant height. In addition, the system also takes into account the needs of different plants and provides a potted plant species selection function, which allows users to choose the appropriate breeding method according to the specific plant species, ensuring a more intelligent and adaptable system.

6. Conclusion

Our system is of great significance in promoting the development of modern agriculture. Facing the problems of shortage of social agricultural workers, low production efficiency and low value-added of agricultural products, our design builds a unique and independent animal and plant breeding system based on technologies such as artificial intelligence, Internet of Things, cloud computing and big data. In addition, our plant and animal breeding system also has the potential for mixed plant and animal breeding in large-scale agro-ecological farms. Through smart WiFi and 3D management functions, the system is able to realize precise management of plants and animals, which improves the efficiency of agricultural production. More importantly, this system helps to solve the problem of environmental pollution, especially in large-scale agro-ecological farms, where our technology can effectively minimize the impact on the environment and provide more high-quality ecological agricultural and sideline products. By enhancing people's aesthetic requirements for a beautiful ecological environment, our work plays an active role in building a more sustainable and healthy agro-ecosystem.

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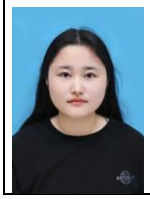

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