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Implementation of an Intelligent Aquaponics System

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ABSTRACT

We use the Arduino mega 2560 control board as the control core and combine various electronic components to complete this intelligent aquaponics system. Achieve the first function: the water level sensor senses the water level and sends the data to the Arduino to control the pumping motor to pump water. As the water recycles, the feces of the fish are extracted to provide plant nutrients. The second function: The photoresistor module detects the external light and sends the data to the Arduino to control the LED lights for lighting the plants.

Keywords: Arduino mega 2560, Aquaponics, SoC

1.INTRODUCTION

Aquaponics, also known as integrated aquaculture and agriculture or combined farming and aquaculture, refers to a system that combines the excrement of aquatic animals with organic matter in the water. which are then decomposed and filtered into nitrate salts that plants can absorb. These nutrients are supplied to vegetables grown in tanks above the aquaculture system. Simultaneously, the vegetable roots purify the water within the system, making it suitable for aquatic animals to use [1]. This creates a mutually beneficial symbiotic ecosystem that integrates aquaculture and hydroponics. [2] In an aquaponics system, water from an aquaculture system is channeled into a hydroponics system, where byproducts are broken down by nitrifying bacteria into nitrate and nitrite, which plants utilize as nutrients. The water is then recycled back into the aquaculture system.

In aquaponics systems, species such as tilapia, koi, or jewelfish can be used. The pond water contains fish waste rich in nitrogen and ammonia. If discharged directly into rivers or soil, it would burden the environment. However, using this wastewater to grow vegetables provides nutrients for the plants. After the vegetables purify the water, it can be recirculated back into the fish pond for reuse. This balanced system prevents water quality deterioration and fosters a mutually beneficial cycle where fish support plants and plants support fish [1-4].

Vegetables grown using aquaponics technology do not require added fertilizers. However, due to variations in system design and the compatibility between fish and vegetable species, certain nutrients may occasionally be deficient and require supplementation—such as iron, calcium, and potassium, which are commonly encountered. During cultivation, due to fish farming, pesticides cannot be used for pest control. Generally, physical methods such as insect netting or organically certified materials can be employed to manage pests.

As times change, land becomes increasingly scarce, making efficient land use more crucial than ever. That's why we developed this system—to reduce the burden on labor while effectively utilizing water through its circulation, thereby minimizing waste of this vital resource. Food contamination is a major concern today, leading to the rise of organic, pesticide-free, and non-toxic agricultural products. However, cultivating these crops presents another challenge: limited land availability. This has spurred the development of aquaponics systems, which integrate fish farming with vegetable cultivation. Requiring less land and significantly reduced water usage, these systems have captured considerable attention from modern consumers.

2. RESEARCH OBJECTIVES

We have set the theme of our project as an intelligent aquaponics system. As times change and land becomes increasingly scarce, we need to utilize land more efficiently. Therefore, we developed this system to reduce the burden on labor. By circulating water, we can use it effectively and minimize water waste. Food contamination is a major concern today, leading to the emergence of organic, pesticide-free, and non-toxic agricultural products. However, cultivating these crops presents another challenge. That's because land is limited, so people began developing aquaponics systems—a symbiotic setup combining fish and vegetable cultivation. Since it requires less space and significantly reduces water usage, it has gained considerable attention from modern consumers.
The trend of global warming makes future food supply and security critical issues we must confront. By growing fish and vegetables together using the same water source in a symbiotic relationship, we not only avoid wasting resources but also utilize them efficiently. The hardware block diagram is shown in Figure 1.

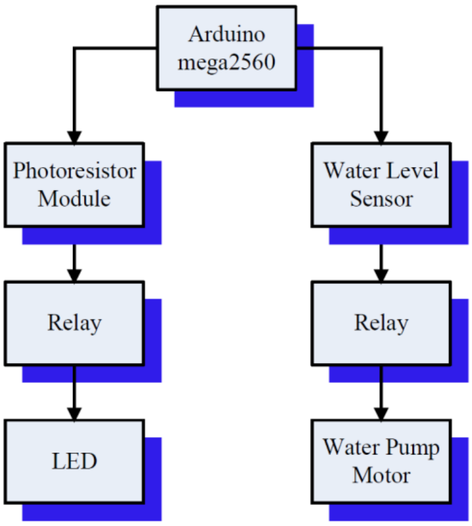

Figure 1: Hardware Block Diagram

3. HARDWARE INTRODUCTION

3.1 Water Pump Motor

As shown in Figure 2, the pump dimensions are 90mm × 40mm × 35mm. The outlet diameter is 6mm inner diameter and 9mm outer diameter. Operating voltage is DC 6-12V, with operating current of 0.5-0.7A. Flow rate: 1.5-2 L/min (approx.). Maximum suction lift: 2 meters. Maximum head: 3 meters. Service life: up to 2500 hours. Water temperature tolerance: up to 80°C.


Figure 2: Water Pump Motor

3.2 Single-Channel Relay Module

As shown in Figure 3, the relay module functions as an “automatic switch” that uses a small current to control the operation of a larger current. It is commonly employed in circuits for safety protection, circuit switching, and similar applications.

Figure 3: Single-Channel Relay Module

Figure 4: Water Level Sensor

3.3 Water Level Sensor

As shown in Figure 4, the Water Level Sensor is a simple-to-use, cost-effective water level/water droplet detection sensor. It determines water levels by measuring the size of water droplets or water volume through a series of exposed parallel conductor traces. It effortlessly converts water levels into analog signals, with the output values directly readable by Arduino development boards to achieve water level alarm functionality.

3.4 Photoresistor Module

As shown in Figure 5, the photoresistor module is most sensitive to ambient light. It is typically used to detect the brightness of the surrounding environment to trigger microprocessors or relay modules. When ambient light intensity falls below the set value, the DO terminal outputs a high electrical level. When ambient light intensity exceeds the set value, the DO terminal outputs a low electrical level. The DO output terminal can be directly connected to a microcontroller, which detects high and low voltage levels to monitor changes in ambient light intensity. The DO output terminal can directly drive a relay module, thereby forming a light-controlled switch. The analog output AO can be connected to the AD module. Through analog-to-digital conversion, more precise measurements of ambient light intensity can be obtained.

Figure 5: Photoresistor Module

3.5 LED Light

As shown in Figure 6, an LED light is a semiconductor electronic component capable of emitting light. It operates through a compound formed by trivalent and pentavalent elements, with a working voltage of 12V.

Figure 6: LED Light

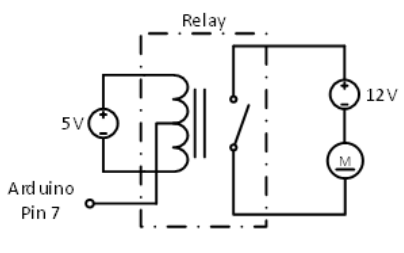

Figure 7: Relay Circuit

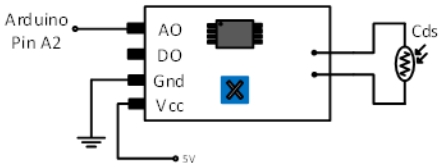

Figure 8: Photoresistor Circuit

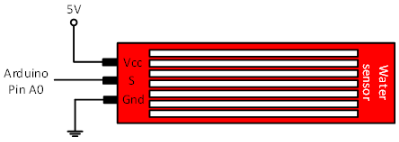

Figure 9: Water Level Sensor Circuit

4. HARDWARE CONSTRUCTION RESULTS

The relay circuit is shown in Figure 7, the photoresistor circuit in Figure 8, the water level sensor circuit in Figure 9, the LED circuit in Figure 10, the complete circuit diagram in Figure 11, the aquaponics diagram in Figure 12, and the Arduino test circuit diagram in Figure 13.

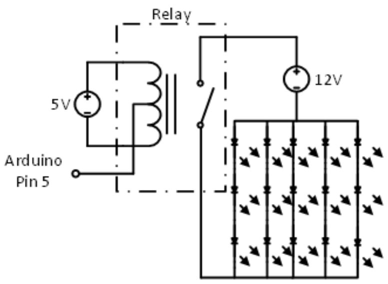

Figure 10: LED Light Circuit

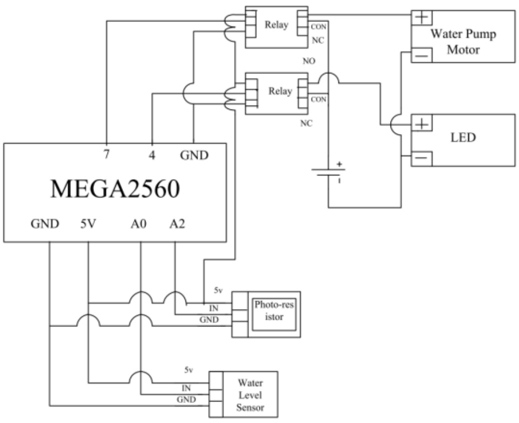

Figure 11: The Complete Circuit Diagram

Figure 12: The Aquaponics System picture

As shown in Figure 14, when the system water level drops too low, the pump automatically operates until the water reaches the preset level, then stops. As shown in Figure 15, when the photoresistor detects insufficient ambient light around the system, it activates the LED to provide automatic illumination.

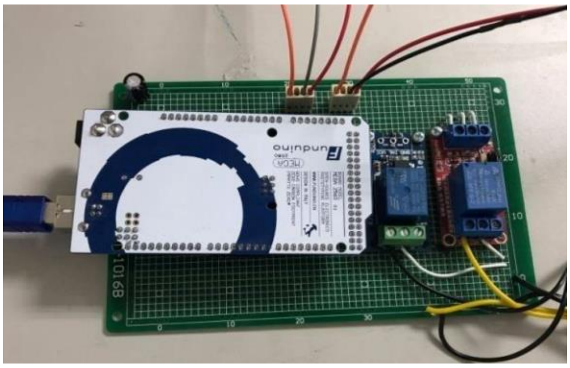

Figure 13: The Arduino Test Circuit Diagram

Figure 14: System Automatic Water Extraction

Figure 15: System Auto-Sensing Lighting

5.CONCLUSION

The completed system entity diagram is shown in Figure 16. We have integrated technology-driven monitoring to create an intelligent aquaponics system featuring automatic water circulation and sensor-activated lighting, eliminating the need for manual maintenance. It is hoped that aquaponics can be widely adopted in modern agriculture through government promotion, enabling more efficient utilization of land and water resources amid the scarcity of modern land and water resources.

Figure 16: The Completed System Entity Diagram

Declaration by Authors

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Conflict of Interest: No conflicts of interest declared.

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