JYOTHI ENGINEERING COLLEGE
CHERUTHURUTHY, THRISSUR 679 531

Main Project

On

INTELLIGENT AQUA FARMS

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EIGHTH SEMESTER B.TECH (ENGINEERING)

DEPARTMENT OF
ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled **INTELLIGENT AQUA FARMS** is being submitted by Amal Thomas K (JYANEEC006), Daniel C Paulson (JYANEEC029), Danish A J (JYANEEC030), David Noyal P S (JYANEEC031) and Kironraj O P (JYANEEC062) in partial fulfilment of the requirements for the award of degree of **Bachelor of Technology** in **Electronics & Communication Engineering** under the **University of Calicut**.

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INSTITUTE VISION

Creating eminent and ethical leaders through quality professional education with emphasis on holistic excellence.

INSTITUTE MISSION

- To emerge as an institution par excellence of global standards by imparting quality engineering and other professional programmes with state-of-the-art facilities.
- To equip the students with appropriate skills for a meaningful career in the global scenario.
- To inculcate ethical values among students and ignite their passion for holistic excellence through social initiatives.
- To participate in the development of society through technology incubation, entrepreneurship and industry interaction.

DEPARTMENT VISION

Create eminent and ethical leaders in the field of Electronics and Communication through quality professional education to excel in academia and industry.

DEPARTMENT MISSION

- Provide theoretical and practical knowledge through quality education and life skills training to make competent graduates with leadership and social commitment.
- To impart entrepreneurial orientation and motivation for research among the students through knowledge transfer between industrial, academic and research institutions.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

I. Graduates shall have fundamental and advanced knowledge in electronics and communication engineering along with knowledge in mathematics, science and computing, and get employed in national or international organizations or government agencies.

II. Graduates shall have the ability to analyze, design and create innovative solutions which lead to a lifelong learning process or higher qualification, making them experts in their profession, thus helping to solve electronics and communication engineering and social problems.

III. Graduates shall have good organizing capability, presentation skills, communicating ability, leadership, teamwork and ethical practices.

PROGRAMME OUTCOMES (PO)

The Programme Outcomes of Under-Graduate programmes in Electronics and Communication Engineering are – students will have:

a. Ability to apply knowledge of mathematics, science and engineering in the field of Electronics and Communication engineering.

b. Ability to design and conduct experiments, analyze and interpret data and results in Electronics and Communication engineering.

c. Ability to design Electronics and Communication systems, components, or processes to meet the desired needs within realistic constraints such as health and safety, manufacturability and sustainability, with economic, environmental, social, political and ethical considerations.

d. Ability to work individually as well as in multidisciplinary teams as a member or as a leader to accomplish the common goal.

e. Ability to identify, analyze, formulate and solve engineering problems.

f. Knowledge of professional and ethical responsibility.

g. Ability to communicate effectively in both verbal and written form in any area of their field, to industry and society.

h. Broad knowledge necessary to understand the impact of engineering solutions on individuals, organizations and society.

i. Ability to engage in life-long learning to update their knowledge to keep pace with changes caused by the dynamic nature of the engineering field.

j. Awareness of contemporary issues that help to integrate advanced and sustainable solutions in the user environment.

k. Ability to use techniques, skills, and modern engineering tools, software and equipment necessary for designing and developing electronic systems.

ABSTRACT

Along with socio-economic development, people have come to pursue higher living standards. However, more time is now spent on work, leaving little time to care for ornamental fish and hydroponic plants. The primary objective of this project is to design a smart monitoring and control device for aquaponics – an eco-friendly system for ornamental fish and hydroponic plants. The significance and specific functions of the system are first described in detail, followed by the architecture, hardware components and software design. The system consists of relay-controlled pumps and sensors that detect humidity, temperature, pH and water level in the fish tank. The data acquired by these smart sensors is analyzed and processed for man–machine interaction. Meanwhile, users can also use a mobile terminal to monitor and control the intelligent aqua farm remotely. The design of the system can promote the rapid development of smart aqua farms.

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1 INTRODUCTION

Energy can neither be created nor destroyed; it can only change form. The source of Earth's energy is the Sun. Seventy-one percent of the planet is covered by water, which stores the Sun's energy. Water changes state into a gas when hot and into a solid when cold. Water in the oceans vaporizes and evaporates on sunny days. Wind blows the vapour inland and, as it rises on reaching land, this causes condensation, and the resulting moisture turns into clouds. Precipitation occurs and the moisture falls as rain. Water runoff causes rivers to flow back to the oceans carrying minerals, and infiltration makes underground rivers flow to the ocean as well. Plankton and other plants grow in the ocean, just as plants grow on land, and the oceans and land evolve and fill with life. Bacteria evolved to clean the ocean and keep the balance. This balanced model is what we mimic with intelligent aqua farms.

Mimicking and modeling the natural processes that sustain life on Earth is critical for humanity as it looks to expand into new frontiers. The biggest challenge is that natural processes take a very long time, while humans live for a comparatively short time, so people take shortcuts – leading to most of the sustainability issues facing the Earth today.

This project involves using modern fabrication technologies to build an aquaponic garden, establishing biological life balances in the garden, assembling the electronics kit and sensors, programming the software, and finally configuring a remote database for monitoring and visualization.

The purpose of this project is to create an electronically monitored system capable of producing vegetables and fish for consumption. In addition to operating without producing any waste water, the system is also designed to provide feedback and monitor the biological components so that any serious problems are detected and displayed on a user interface. The project is considered successful when the system operates for over one month with a grow bed full of healthy vegetables and a tank full of live fish.

This report explores the design requirements for the project, as well as the final design and alternatives that were considered during the research and construction phases. After providing background in the fields of aquaponics and electronic systems, this report examines the requirements that the completed prototype must meet to be considered successful. Alternative design choices, and the reasoning behind the selections that were made, are also discussed. Finally, the proposed design is outlined, along with the progress made thus far.

2 LITERATURE SURVEY

Compared to traditional farming, hydroponics has the potential to produce food far more efficiently. Most hydroponic systems use a soil-less medium, eliminating the need for crop rotation, irrigation, or the other complications that come with soil. Hydroponic gardening also uses around 85–90 percent less water than a normal garden, since water that would normally be lost through runoff is instead recycled through the system.

There are, however, a few obstacles to hydroponics – to be commercially profitable, a considerable amount of equipment and space is required. In the spirit of being a controlled system, most operations are also conducted indoors, safe from harsh weather or pests. Also, with no soil, nutrients must be supplemented manually, which can become quite costly from a hobbyist's perspective. Aquaponics takes all of the same principles from hydroponics, but adds fish into the equation to solve the fertilization problem.

The cycle starts with fish producing ammonia; nitrifying bacteria convert this ammonia into nitrate, and plants remove the nitrate from the water before it cycles back to the fish to start again. Cutting the cost and time spent adding nutrients to the water is the largest benefit aquaponics has over hydroponics. In a perfect aquaponic system, the only input required would be food for the fish. Compared to fertilizer, fish food is cheap, and automatic fish feeders are not a new idea. In larger operations, the fish themselves become another product – with separate tanks for spawning, a healthy fish population could potentially be maintained indefinitely.

With advances in technology and the improvement of people's living standards, ornamental fish and hydroponic plants have become an integral part of daily life [1]. Ornamental fish and hydroponic plants not only decorate the environment but can also delight us. However, traditional plant cultivation has mainly been performed in soil, and a series of drawbacks can be found in this approach – for example, regular watering and fertilizing require more time and labour [2]. With the development of various techniques, soil-less cultivation has become a more mature and popular choice, such as in aquaponics [3]. Aquaponics is an eco-friendly system for cultivating fish and crops without soil, by utilizing aquaculture and hydroponics [4]. At present, aquaponics is mainly used in agricultural production. Balcony agriculture and family farming have a greater need for such a technique, as it not only increases ornamental value but also achieves an eco-friendly system. It is an inexpensive symbiotic cycle between fish and plants, so the system can save water more efficiently.

Modern people are always engaged in work and have little extra time to care for ornamental fish and hydroponic plants. On the one hand, ornamental fish consume oxygen and it is tedious to replenish it, maintain temperature, and provide adequate illumination; on the other hand, plants need frequent watering and fertilization. The whole process is complex and time-consuming. Based on these shortcomings, automatic control systems have been proposed [5]. Unfortunately, current automatic control systems are not always stable, and unexpected errors can occur – particularly, it is difficult to realize remote monitoring and control. Consequently, it is necessary to design a smart monitoring and control system, especially for people who travel frequently.

It was found that considering the following parameters is important for the better productivity of an aquaponics system:

- **Sensors:** What type of sensors are ideal for measuring water and air temperature, pH levels, dissolved oxygen, nitrogen by-products, and the many other components involved?
- **Water quality:** What is the optimal method to filter out solid fish waste and introduce the necessary bacteria into the system?
- **Hydraulics:** What size of pump is needed to maintain the optimal flow rate? What diameter of pipe optimizes water flow and reduces pump power? What is the best pipe design and connection layout to move water from one tank to another?
- **System design:** What are the optimal ratios between fish-tank volume and grow-bed volume? What is the optimal drop in water level between components to utilize a gravity-fed system?
- **Engineering economy:** What is the rate of return on the system, based on local labour and electricity costs? Is it profitable, and if so, for which markets?
- **Data collection and monitoring:** What type of system is cost-efficient for collecting sensor data and making it available for remote monitoring over the Internet?

It was found that nobody had approached farming in a scientific or engineering manner for better cultivation, so addressing these considerations can substantially improve food and fish production.

3 PROPOSED METHODOLOGY

The environment monitoring system is mainly made up of a temperature sensor, humidity sensor, ultrasonic sensor and pH sensor. The system also includes solar integration for power consumption, an automatic fish feeder operating on a time-based schedule, and air and water pumps. The architecture of the intelligent aqua farm is shown in Fig. 3.1.

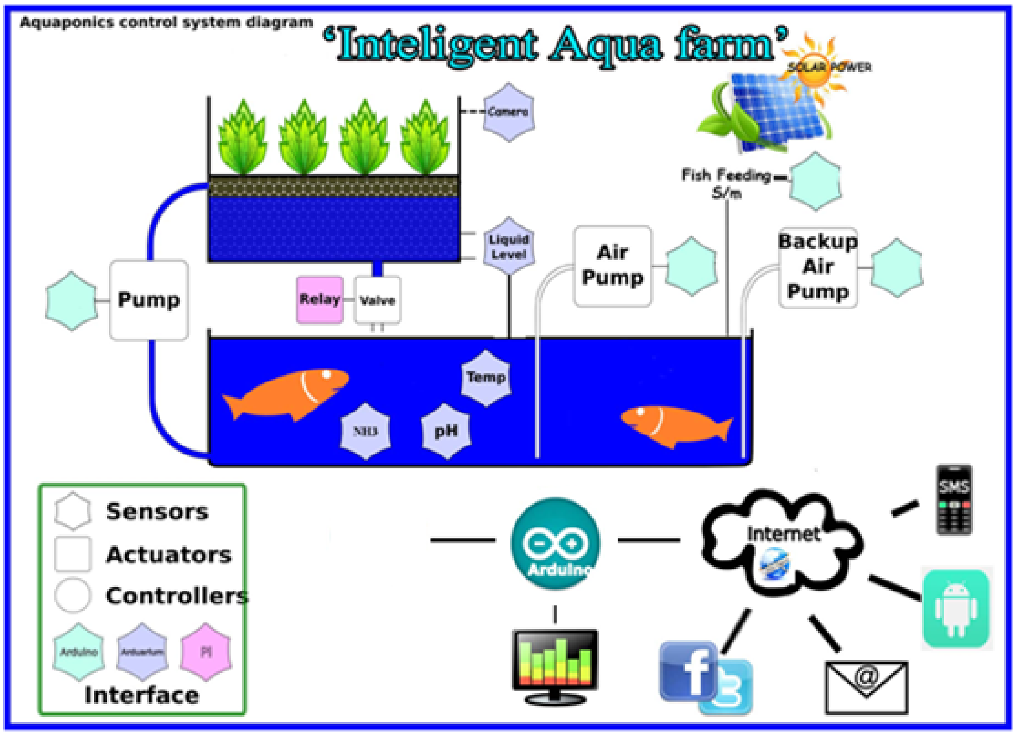

Figure 3.1: Block diagram of intelligent aqua farm

4 HARDWARE IMPLEMENTATION

4.1 Aquaponics System

Aquaponics is an integrated system that links hydroponic plant production with recirculating aquaculture. Hydroponics is a term used to describe plant production without soil – plant roots grow in a nutrient solution, with or without an artificial medium for mechanical support [4, 7]. Aquaculture, also known as aqua farming, is the farming of aquatic organisms and is the fastest-growing sector of the world food economy, increasing by more than 10 percent per year [4]. It is an inexpensive symbiotic cycle between fish and plants, and consequently it is necessary and worthwhile to conserve energy. In this project, a compact aquaponics system was designed for household use.

4.2 DHT22 Temperature Probe

The DHT22 sensor provides the fish tank water temperature reading. It is housed in a box facing away from the fish tank. A cover plate protects the sensor from the elements but gives easy access to it in the event that it fails at any time – this easy access allows the sensor to be replaced if need be. It is joined to each container using a cable gland that keeps the connection watertight. The probes feed into an RJ-45 housing, where connections are made that allow the sensor readings to be passed on to the microcontroller for processing and data display via IoT.

Figure 4.1: DHT22 Temperature Probe

4.3 Ultrasonic Distance Sensor

This sensor is mounted to the lid of the fish tank, which is covered by the grow bed of the balcony garden. It is housed in a 2-inch black ABS pipe positioned above the fish tank. Both ends of the housing can be removed, giving easy access to the sensor in the event that it fails at any time and needs to be replaced. It helps to determine whether there is any leakage in the tank and to measure the drainage of the system.

Figure 4.2: Ultrasonic Distance Sensor Module

4.4 Arduino

Arduino is an open-source electronic platform, comprising both hardware and software, used to design, develop and test complex electronics prototypes and products. The hardware consists of a microcontroller along with other electronic components that can be programmed using the software to perform almost any task. The simplicity of the Arduino language makes it very easy for almost anyone with an interest in electronics to write programs, without needing to understand complex algorithms or code. Arduino is intended for artists, tinkerers, designers, or anyone interested in playing with electronics without prior knowledge of complex electronics and programming skills. It is an excellently designed open-source platform, with specially designed boards that can be programmed using the Arduino Programming Language (APL).

Over the years, Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers – students, hobbyists, artists, programmers and professionals – has gathered around this open-source platform, and their contributions have added up to an incredible amount of accessible knowledge that can help both novices and experts alike.

Arduino has been used in thousands of different projects and applications. The Arduino software is easy to use for beginners, yet flexible enough for advanced users, and it runs on Mac, Windows and Linux. Teachers and students use it to build low-cost scientific instruments, to demonstrate chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, while musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at events such as the Maker Faire. Arduino is a valuable tool for learning new things – anyone, from children and hobbyists to artists and programmers, can start tinkering just by following the step-by-step instructions of a kit or sharing ideas online with other members of the Arduino community.

There are many other microcontrollers and microcontroller platforms available for physical computing – Parallax Basic Stamp, Netmedia's BX-24, Phidgets, and MIT's Handyboard, among others, offer similar functionality. All of these tools handle the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantages for teachers, students and interested amateurs over other systems:

- **Inexpensive** – Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled modules cost less than $50.
- **Cross-platform** – The Arduino Software (IDE) runs on Windows, Macintosh OS X and Linux, whereas most microcontroller systems are limited to Windows.
- **Simple, clear programming environment** – The Arduino IDE is easy to use for beginners yet flexible enough for advanced users. For teachers, it is conveniently based on the Processing programming environment, so students learning to program in that environment will already be familiar with the Arduino IDE.
- **Open-source and extensible software** – The Arduino software is published as open-source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and those wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it is based; AVR-C code can similarly be added directly into Arduino programs.
- **Open-source and extensible hardware** – The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can create their own version of the module, extending and improving it. Even relatively inexperienced users can build the breadboard version of the module to understand how it works and save money.

The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32 KB of ISP flash memory with read-while-write capability, 1 KB of EEPROM, 2 KB of SRAM, 23 general-purpose I/O lines, 32 general-purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire serial interface, an SPI serial port, a 6-channel 10-bit A/D converter (8 channels in TQFP and QFN/MLF packages), a programmable watchdog timer with internal oscillator, and five software-selectable power-saving modes. The device operates between 1.8 and 5.5 volts. By executing powerful instructions in a single clock cycle, it achieves throughput approaching 1 MIPS per MHz, balancing power consumption and processing speed. Today, the ATmega328 is commonly used in many projects and autonomous systems where a simple, low-power, low-cost microcontroller is needed – perhaps the most common implementation of this chip being on the popular Arduino development platform, namely the Arduino Uno and Arduino Nano.

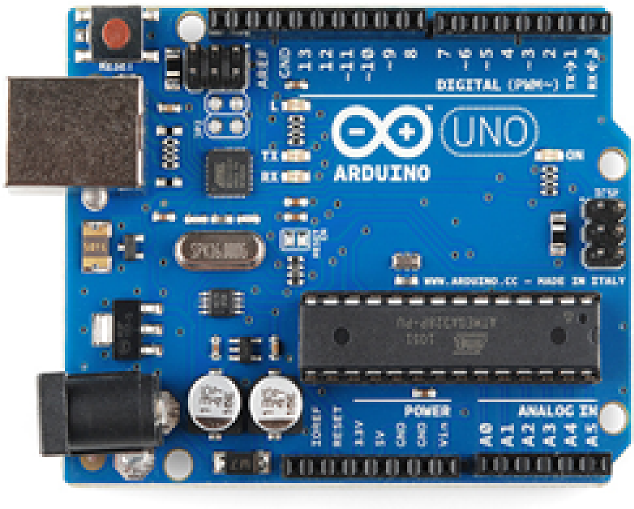

Figure 4.3: Arduino

4.5 Float Switch

This switch is located in the fish tank of the balcony garden. It feeds into an RJ-45 housing, where connections are made that allow the switch signal to be passed on to the microcontroller for processing and data display via IoT.

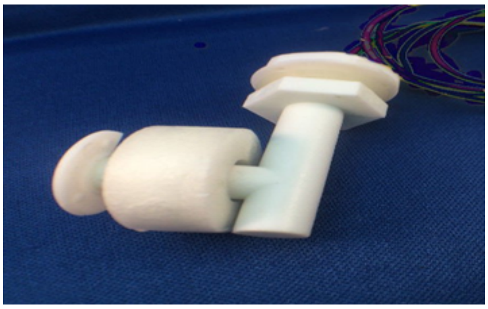

Figure 4.4: Float switch

4.6 Relays

- The main power supply is controlled by a relay – power can be turned on and off remotely over the Internet, or automatically if a system failure is detected.
- The grow-bed valve control relay controls the valve that fills and drains the grow bed of the balcony garden.

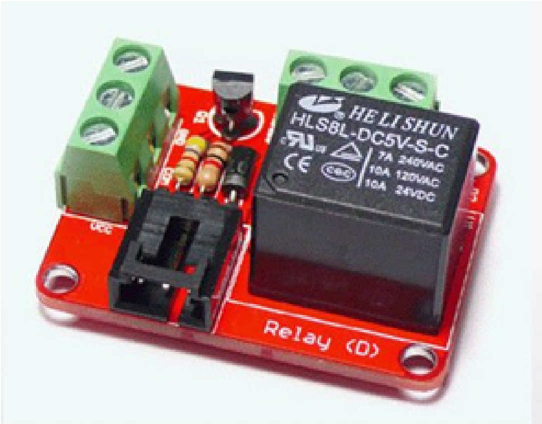

Figure 4.5: Relay

4.7 pH Sensor

The pH sensor monitors the acidity and alkalinity of the water in the fish tank, which has to be maintained between 5 and 9.

Figure 4.6: pH probe

4.8 Solar

Solar power is used for better energy efficiency, where all the motors and sensors can be driven by solar power even when the main supply is cut off by the relays.

Figure 4.7: Solar cell

4.9 Automatic Fish Feeder

The automatic fish feeder operates using timer signals, which trigger a valve-controlled mechanism that is activated at scheduled times. It can also be controlled manually to change the amount of food dispensed, in accordance with the fish quantity.

Figure 4.8: Automatic Fish Feeder

5 CONCLUSION

This study designs a smart monitoring and control system for aquaponics based on an Arduino and a Wi-Fi shield, which is intelligent, accurate and real-time, and which can release users from demanding working conditions. As one of the typical applications of the Internet of Things (IoT), more and more people are realizing that IoT will bring broad development to the smart life. Meanwhile, the aquaponics device can be connected to social communication platforms, allowing people to interact with their ornamental fish and hydroponic plants through a mobile terminal as well.

6 FUTURE SCOPE

To date, aquaponics has been pursued primarily by aquaculturists through aquaculture and fisheries agencies, despite the fact that it is primarily a horticultural activity. There needs to be a rebalancing of effort and support, primarily through agricultural training and extension, but also through joint initiatives between fisheries and agriculture services where appropriate. Aquaponics has not been adopted on a large scale due to a number of factors, including the complexity and difficulty involved in constructing and monitoring these systems.

It was the purpose of this project to build a system that would provide a test bed for spectrum-targeted LED grow-light creation and to show that scalable aquaponic monitoring systems could be implemented commercially. The goal was to present beneficial research and a proof of concept in the electronic aspects of aquaponics, so that hobbyists and companies can continue to improve and expand upon their aquaponic endeavours. This goal was reached, and the system does produce vegetative growth in a sustainable ecosystem with spectrum-targeted LED lighting, electronic monitoring, and automatic alerts.

There were, however, some mistakes made during the course of the project that should be improved upon if a similar project is attempted in the future. As mentioned above, the choice to use gravel as a cost-saving measure – despite many warnings found during preliminary research – was a mistake that resulted in a great deal of wasted time and money; if this project were attempted again, expanded clay pebbles should be used from the outset. Additionally, to prevent nutrient deficiencies in the plants grown in the grow bed, the fish tank should be stocked adequately according to the ratios outlined in Bernstein's book, even if some of the population has to be culled or sold later.

Lastly, the electronic components should be selected with specific attention paid to minimizing the overall development time of the system. Not enough focus was placed on the communication protocols used within the electronic subsystem, and as a result each sensor and the display communicated in a different fashion. As discussed above, each communication protocol must be properly initialized and configured in order to work effectively on the microcontroller. Further, each of those components must operate together in both hardware and software – such as within an interrupt service routine – without interrupting the functional processes of any other component. Communication and compatibility remain an area that requires attention in this project, and one that will be continually examined and improved upon in the future.

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