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Automatic Monitoring and Control of Shrimp Aquaculture and Paddy Field Based on Embedded System and IoT

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Abstract— **Aquaculture is the farming of aquatic organism in natural or controlled marine or freshwater environments. The real-time monitoring of environmental parameters are very important for both shrimp aquaculture and paddy farming. Here, an electronic system is proposed for the efficient monitoring and effective control of different environmental parameters related to the paddy field and shrimp aquaculture. The proposed system is implemented as an embedded system to monitor and control the important environmental parameters with the help of sensors and actuators. A set of different types of sensors are placed in the cultivation field and each of them are connected to a common microcontroller board built on an Arduino UNO board. The micro-controller will monitor the sensor values and these real-time values are shared to a data logging system implemented on a Raspberry Pi based single board computer. The real-time sensor values can be logged into the SD card of the Raspberry Pi. The actuators such as pump and aerator will be turned on and off automatically by the Raspberry Pi in accordance with the threshold values of different environmental parameters. Moreover, the farmer is also given a facility to control the pumps and aerators through a latest trend in embedded system technology called the Internet of Things(IoT). The farmers can use a social media open-source Android app called Telegram for monitoring and controlling the system. Also, the real-time temperature and humidity values from the sensors are validated by using the information collected from a weather forecasting website. If any abnormality in the environmental parameters are observed, the system will notify the farmer by generating alert SMSs through a web-service application called Twilio. The installation of such a system in the paddy field will definitely help the farmers to increase the yield in a better environmental condition.**

Keywords—Arduino UNO board; Raspberry Pi; Internet of Things; Telegram ; Twilio

I. INTRODUCTION

India is an agricultural nation and more than 50% of population employed in agricultural field. Shrimp farming is an aquaculture business that exists in either a marine or freshwater environment, producing shrimp or prawns for human consumption. A freshwater prawn farm is an aquaculture business designed to raise and produce freshwater prawns or shrimp for human consumption. In recent years, the development of shrimp farming has been rapidly improving in the southern region of India. India has the largest paddy output in the world and is also the fourth largest exporter of rice in the world. Kuttanadu is called the rice bowl of Kerala.

A. Background Study and Overview

Pokkali farming is a system in which paddy and shrimp are grown alternately in the same field. The rice is cultivated from June to early November when the salinity level of the water in the fields is low. From mid-November to mid-April, when the salinity is high, prawn farming takes over. The brand Pokkali has received a GI (Geographical indication) tag from the Geographical Indications Registry Office, Chennai. Pokkali is a unique system which combines rice cultivation as well as prawn culture in the same field. Traditionally only one crop of rice is taken in a year; the rest of the season prawn farming is done in a traditional manner. The main farming practice of Kuttanad area is rice cum fish culture in the traditional paddy fields.

The best utilization of ecological cycle takes place in Pokkali fields making it environmental friendly. Absence of the use of chemical fertilizers and pesticides makes it an organic rice production system with less expenditure compared with normal rice cultivation. The major environmental concerns of loss of biodiversity, over exploitation of natural resources and coastal degradation are not present in this system. This system is an eco-friendly cultivation practice.

Usually, shrimp farmers use mechanical paddle-wheels that have to be turned on and off manually to slap, beat and chum oxygen into the surface of the water. The system is operated manually based on experience and not based on any actual measurement mechanism. The monitoring of the cultivation field on a regular basis and a mechanism for automated control automation is essential.

Nguyen Tang Kha Duy et al.[1], proposes a versatile solution in an effort of improving the accuracy in monitoring the environmental conditions and reducing manpower for industrial households shrimp farming. A ZigBee-based wireless sensor network (WSN) was used to monitor the critical environmental conditions and all the control processes are done with the help of a series of low power embedded MSP430 microcontrollers from Texas Instruments. This system is capable of collecting, analyzing and presenting data on a Graphical User Interface (GUI), programmed with LabVIEW. It also allows the user to get the updated sensor information online based on Google Spreadsheets application, via Internet connectivity, or at any time through the SMS gateway service and sends alert message promptly enabling user interventions when needed. However the proposed system has some limitations in the range of communication. And does not provides world wide control of actuators from the farmer.

Jyotirmoy Bhardwaj et al.[2], present new concepts and techniques are replacing traditional methods of water quality parameters measurement systems. In modern sensor era, Optical Sensors (OS), Microelectronic Mechanical Systems (MEMS) and Bio Sensors are important sensing techniques for different water quality parameter detection. Furthermore, these sensors are highly selective, sensitive, economical and user-friendly with quick response. This paper comprehensively reviews and discuss role of emerging techniques in detection of important water quality parameters i.e Dissolved Oxygen, Turbidity, pH, E-Coli, Effective chlorination, Biochemical Oxygen Demand (B.O.D) and fluoride.

The evolution of wireless sensor network technology has enabled us to develop advanced systems for real time monitoring. In the present scenario wireless sensor networks are increasingly being used for precision agriculture. The advantages of using wireless sensor networks in agriculture are distributed data collection and monitoring, monitor and control of climate, irrigation and nutrient supply. Hence decreasing the cost of production and increasing the efficiency of production. Santhosh Simon et.all describes the application of wireless sensor network for crop monitoring in the paddy fields of kuttand, a region of Kerala, the southern state of India [3].

Bodepudi Srinivasa Rao et.all[4] presents Monitoring system of aquiculture with automatic control system using arm 7. This monitoring system consists of PC host computer, slave computer in which the ARM7 Controller. The PC will used to settle the system, control parameters, data processing, analysis and display, the other one is a slave computer, whose core is ARM7 Controller. Slave computer can measure and control the environmental factors of breeding system, that is, it can convert the collected data and store it as digital signal. Slave computer has data collecting module, data storing module, control module, power module, display module and Automatic control system. The slave computer is a close-loop control system, so that, it can individually accomplish environment factors Like temperature, PH, dissolved oxygen, etc. measured. The wireless communication module is used to transfer data between host computer and slave computer. This system can realize control of the aquaculture environment factors. With the help of expert system, the system can achieve real-time monitoring, data collection, read, store and compared with the set points. If these values exceed their corresponding set points, the system displays the fault indication message on the LCD with sound alarming. After alarming once rising problem automatic control motors are automatically ON, this environmental factors to reach set points, Motors are Automatically OFF. So as to realize Energy saving, Safe, increase output, Lower the labour intensity and improve efficiency [5]. However it does not utilize ARM features efficiently.

II. PROPSED SYSTEM DESIGN

The proposed system uses a methodology which is based on Raspberry Pi single board computer.

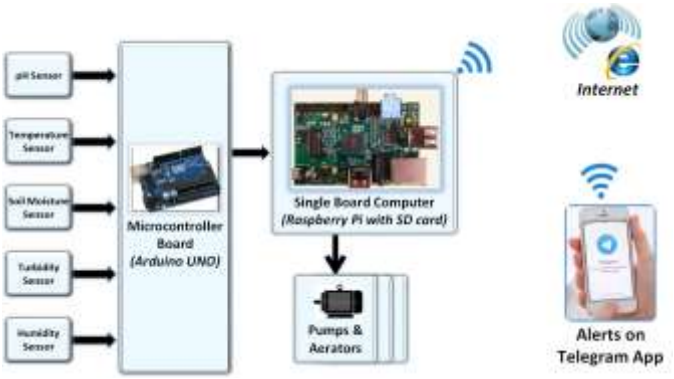

Figure.1: Block Diagram

Figure.1. shows the block diagram of the system. In brief, Dissolved Oxygen, pH, Temperature and Proper management (feed and health) are the critical factors to be taken care of in shrimp farming. According to the system mode, the system parameters will changes. In shrimp farm management, the system will monitors the ammonium content, dissolved oxygen level in water. According to the farm parameters corresponding actuators will turn on and off. Here our system will controls the dissolved oxygen by operating the aerators. Ammonia and Nitrates used to have high negative impact on shrimp health. These are generated in water due to the excess of food in the water. These are controlled my monitoring the pH value of water. pH value will vary in accordance with the ammonia contents. These are controlled by pumping the alkaline solution to the water. In the case of paddy field, the system will monitor the pH level, soil moisture and weather conditions. According to the water content in the land we can turn on the pump from any distance. Because the whole system is connected to the Internet. The motor will on by validate the sensor value with the information from the pyOWM website [5]. It also controls the soil pH. This system

can monitor and controls up to 1 acre of land. All the parameters can monitor on user phone. And control the pump through the farmer phone. The controlling of the farm is achieved through the telegram application [6][7]. And the abnormality of the farm will notifies the farmer through messages generated by twilio application [8]. The proposed system consist of three main sections.

- A microcontroller based monitoring system
- A single board computer based data logging system.
- User alerts.

In the sensor section a microcontroller will collect information from the farm through the sensors. Mainly five sensor modules - temperature sensor, humidity sensor, pH sensor, soil moisture sensor and turbidity sensor - are used. The proposed system uses an arduino UNO board as micro controller.

In the actuator section arduino controller is serially connected to the single board computer(raspberry pi). Raspberry pi is connected to the internet and the actuators. The informations of the farm is logged in the SD card. When the sensor values cut the threshold value, the actuators will turned ON & OFF automatically by the single board computer.

The user mobile phone is the user interface section. That is conncted to the internet. The phone which is available with telegram open source android application. Telegram application provide world wide control on actuators. It will receive the SMS for abnormality in the cultivation field through twilio application. The features of the proposed system prototype are as follows.

- Automatic monitoring of key environmental parameters: The system propose a method for monitoring continuous data that can be used to identify abnormalities and improve production. The proposed system monitors the critical parameters such as dissolved oxygen and pH. Soil moisture and acidity are monitored for the paddy farming. The system will continuously measure environmental parameters and records those parameters, based on the sensor values. These parameter values logged in the SD card for future use for comparison of existing with the previous for better production.
- Automated controlling of the actuators: The actuators will turn on when abnormalities in the cultivated field are observed. The abnormality of the cultivation field indicates the deviation from the threshold values of temperature, humidity, turbidity, pH, soil moisture etc.
- Controlling of actuators using Internet of Things(IoT): The system provides the facility for the control of the farm from anywhere in the world through the internet. This is done through actuators that can be controlled through the internet.
- Utilization of social media open-source Android app called Telegram. The system uses Telegram android application for the monitoring and controlling of the farm.
- Validation of real-time sensor data with the information obtained from weather forecasting websites: Real time values of sensors may have some changes due to the damages of the sensors. It will make a negative impact on the system. So the system provides a facility that some parameters are controlled by validating the sensor value with the weather information from the websites.
- Alert SMS to indicate the abnormality of the environmental parameter: The abnormality of the farm indicates the deviation of actual values from the threshold value of the sensor parameters. That will notifies the farmer by generating an alert SMS through twilio application.

A. Hardware Requirements

The main hardware component utilized for system design are Arduino UNO, Raspberry Pi, sensors and actuators.

1) Arduino UNO: The microcontroller chip used in this board is Atmega328 IC which is a very popular microcontroller chip manufactured by Atmel. It is a high performance 8-bit AVR microcontroller with RISC architecture. The features of this microcontroller include 32 KB ISP flash memory with read-while-write capabilities, 23 GPIO lines, 1 KB EEPROM, 2 KB SRAM, 32 general purpose working registers,internal and external interrupts, three flexible timer/counters with compare modes, serial programmable USART, a byte oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The operating voltage of the device is between 1.8 volts to 5.5 volts. It executes one instruction in each clock cycle hence the throughput is high (1MIPS per MHz) and there is a balancing of power consumption and processing speed. This is a simple, low cost and low powered microcontroller and so it is used commonly in most autonomous systems.

2) Raspberry Pi: The Raspberry Pi may be a computer all on its own, but still need a lot of other things to make it work. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. Figure.2. shows Raspberry Pi has several models like model A, model A+, model B , model B+, generation 2 model B (2B) etc. Third generation model B Raspberry Pi is used in the project. The main specifications of 3B Raspberry Pi are 1GB SDRAM memory, 4 USB ports, 40 GPIO pin out, 900 MHz quad core ARM Cortex A7, HDMI (High Definition Multimedia Interface) video out, maximum 32Gb SD card support, micro USB power cable connection, Ethernet connectivity, no ADC and no VGI (Video Graphics Interface) out.

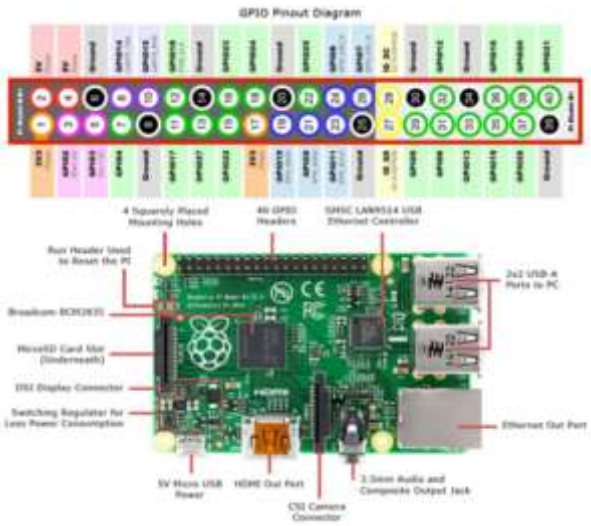

Figure.2: Second generation model B Raspberry Pi

B. *Software Requirements*

The programming of microcontroller is done by using Arduino software. Arduino is an open source platform and the advantage of programming in Arduino is the hardware debugger support. Arduino is based on embedded C language. The program code sketched in this software can be directly burned in to Microcontroller.

Python is a widely used high-level, general-purpose, interpreted, dynamic programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library. Python interpreters are available for many operating systems, allowing Python code to run on a wide variety of systems. Using third-party tools, such as Py2exe or Py installer, Python code can be packaged into stand-alone executable programs for some of the most popular operating systems, so Python-based software can be distributed to, and used on, those environments with no need to install a Python interpreter.

C. *Software Architecture*

The software architecture of the Raspberry Pi section is shown in figure.4. The following are the main tasks written in python.

- Read the sensor values: One of the main task of the proposed system is to collect information about the environmental parameters from the cultivation field.
- Automatic controlling of actuators: When an abnormality occurred in the cultivation field, pumps and aerators are automatically turned ON and OFF by the raspberry pi. The abnormality in the cultivation field indicates variation of parameter values from threshold value.
- Collect weather information from websites: Access the weather information like temperature and humidity from websites to validates the sensor information.
- Controlling of actuators through telegram: A unique feature of the system is to control the pumps and aerators through the internet.
- SMS alert through Twilio application: Provide alert message to the farmer on abnormality in the cultivation field. Abnormality indicates the variation of environmental parameters from threshold value. The generated message contains status of the environmental parameter and the actuator

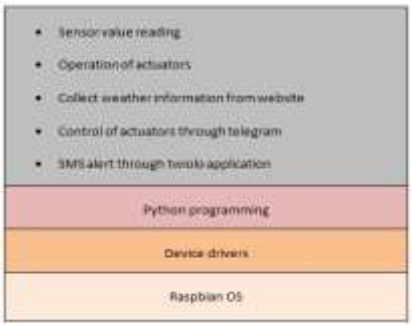

Figure.4: Software Structure

III. DEVICE OPERATION

The device is composed of a sensor section interfaced with actuator section. When the power is turned ON, the system will take a few seconds to initialize. After initialization, the system starts collecting the information from different sensors. The implemented system has two modes of operation.

- Shrimp mode operation
- Farm mode operation

Figure.5. Telegram user interface for controlling

At the initial state the system is in farm mode operation. The farm mode can be change in to shrimp mode by choosing shrimp mode in the telegram application. In shrimp mode operation the system will collect the information such as pH, temperature, humidity and turbidity. Information can be view by using telegram application. In farm mode operation system will use the information such as temperature, humidity, soil moisture and pH for the successful operation of paddy field. The actuators on the cultivation field can control through the telegram using JSON keypad shown in figure.5. Alert messages delivered to the farmer mobile through twilio application to indicate the abnormalities.

IV. Result and Analysis

Figure.6. shows the image of the hardware prototype model.

Figure.6: Image of hardware prototype

The system prototype was tested by dipping the temperature sensor in the water of a shrimp farm environment. The readings such as temperature and dissolved oxygen monitored by the system. In day time the temperature level of water is less compared to atmospheric temperature, but in night time water temperature is high compared with atmospheric temperature due to the land breeze and sea breeze. Similarly, the dissolved oxygen level was decreased in night time. Figure.7. shows the temperature, dissolved oxygen level measured by the system.

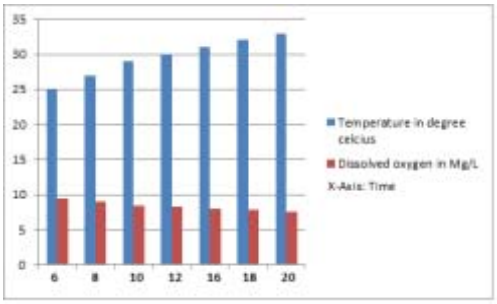

Figure .7: Temperature & dissolved oxygen level variation with respect to time

In recent years, the technology has changed the farmers in the way by which they manage their farmland. The concept of monitoring and controlling the environmental parameters of a farm using embedded system and IoT is a low cost, ease-to-use and flexible to implement electronic system. A working prototype model of the above concept is implemented as an embedded system and the whole system is successfully tested. The system is capable of monitoring both the shrimp farm and the paddy farm parameters such as temperature, pH, dissolved oxygen level and soil moisture with the help of various sensor modules representing these environmental parameters. The controlling of the farm parameters is achieved by using different types actuators. The automatic control of environmental parameters are possible by activating the pumps and aerators if any of the sensor values exceeds its threshold level. The farmers can also monitor farm parameters and control the actuators using a social media Android application called Telegram. The sensor values are also validated by the data collected from pyOWM weather forecasting website. Alerts SMS to farmers are generated when abnormalities in environmental parameters are observed. The whole system can be easily integrated into small and medium sized shrimp farms and paddy fields with minimal modifications. The concept of this system will be very useful for the farmers to reduce their labour and thereby improving the profit.

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