IoT Based Aeroponics Agriculture Monitoring System Using Raspberry Pi

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***Abstract**: Aeroponic has several advantages over traditional agriculture, aimed to improve the efficiency and environment impact of agriculture.This technique contains monitoring and automation for proper operation. Automatic monitoring aeroponic-irrigation system is based on IoT and Raspberry Pi. Analog and Digital sensors for measuring the temperature, humidity, pressure, pH, water flow and level of a nutrient solution. Meanwhile, the control system was used to manage actuators. Sensor's data are transmitted via internet into server in order to facilitate easier monitoring for users. The prototype of the system is successfully implemented and provide a sensor's data.*

IndexTerms **- Aeroponics,growing chamber,monitoring system,control system,sensors**

I. INTRODUCTION

Aeroponics is a culture technique where the plant roots are suspended in the air and they are intermittently sprayed with a nutrient solution. This technique has been used both in research and crops commercial production. Aeroponics present great adventages over traditional agriculture, like reduce the consumption of water and nutrients, increased of growth rate, plant density and therefore of the irrigation system. Continuous monitoring the consumption and the level of the nutrient solution, as well as the correct operation of pumps and values, because a system failure could cause crop loss, due to the lack of substrate of plant.

The data transmission should be the main concern of aeroponic growing chamber monitoring and control. This paper presents an alternative method for monitoring and monitoring aeroponic using wireless sensors.

II. EXISTING SYSTEM

The general concept of the proposed system is shown in Fig.2 The system is consisted in 2 parts, namely monitoring & control system and solar panel system. This system shall enable automation for the related actuators with a user-defined settings.. The growing chamber that used in this research is a 50x40x20 cm box. From [12], the coverage of sensor nodes for agricultural application must be dense (i.e. 1 sensor/m2) so this chamber only need one sensor per parameter. For online monitoring, sensors (pH, temperature, and light) data will be transmitted to server and displayed on a website .

The system consists of sensors, microcontroller, actuators and communication module, which monitor and control several parameters on growing chamber : temperature, water pH, and light intensity. The sensors that was used in this research are LM35 (temperature sensor), pH sensor, and LDR (light intensity sensor). This microcontroler is programmed using Arduino IDE. On the actuator, there are two relay, that activate Ultrasonic mist maker and fan on specific cycle time interval. The following are specifications for the desi

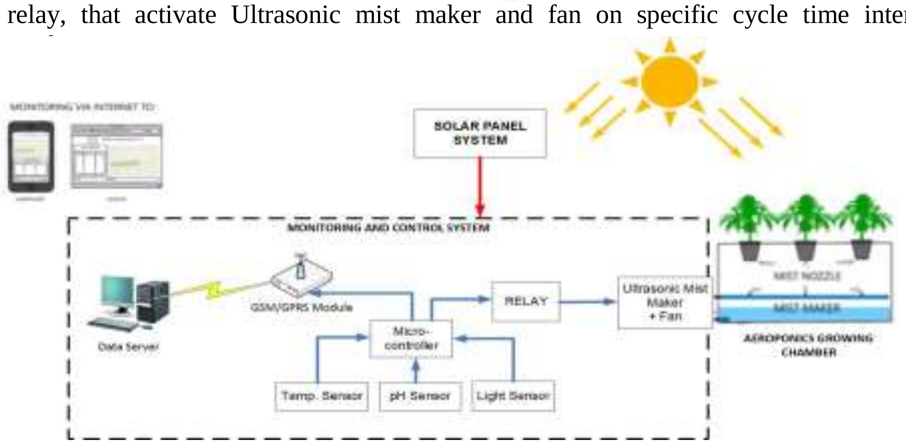


Fig.1 System design.

• System would be able to measure growing-chamber's temperature, pH, and light intensity. monitoring and control. Using Short Message Service (SMS)

• This system control timer for ultrasonic mist maker and was applicable for the purpose but it's inefficient in terms of fan activation cost. They recommend that these results are taken into account

•Sensor measurements will be displayed on a website through utilizing more efficient data transmission method from

•System is designed to transmit data using GSM/GPRS. the growing chamber to server such as GSM/GPRS/3G modem.

Table I summarized the reference/guidelines for monitoring and control system deployment in agriculture application.

pH Sensor Subsystem

For pH levels data acquisition from the nutrition tank, a pH sensor, Lutron PE-03 (Fig.4) is used. The output of this sensor is connected to a signal conditioning circuit (Fig.5) that amplify the output signal while transmitting it to the ADC pin of the microcontroller.

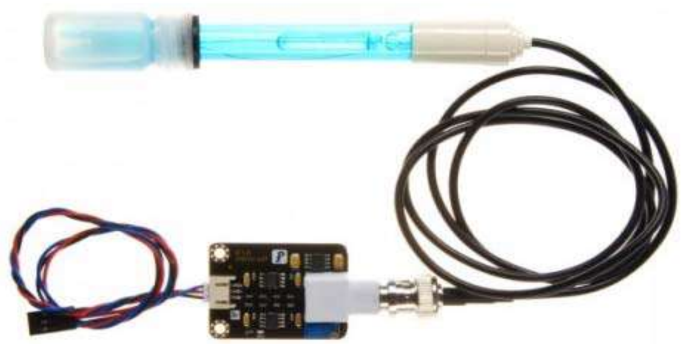


Fig.2. pH Sensor

Solar Panel System.

Solar Panel System consists of Solar Panel, Solar Charge Controller, Battery, and DC-to-AC inverter. This module convert light energy from the sun to electricity. Solar charge controller regulates the solar panel output to charge the battery. The inverter is used to convert from DC to AC.

Fig. 3. Solar panel system

Light Sensor Subsystem

Light sensor is used to obtain light intensity measurements. It works based on a principal that it will generate current which will be proportional to the received light intensity. This sensor is also needed to be connected to signal conditioning circuit before connected to microcontroller.

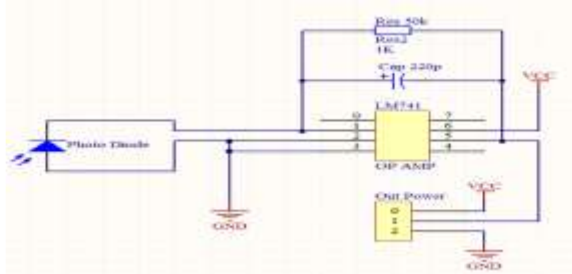
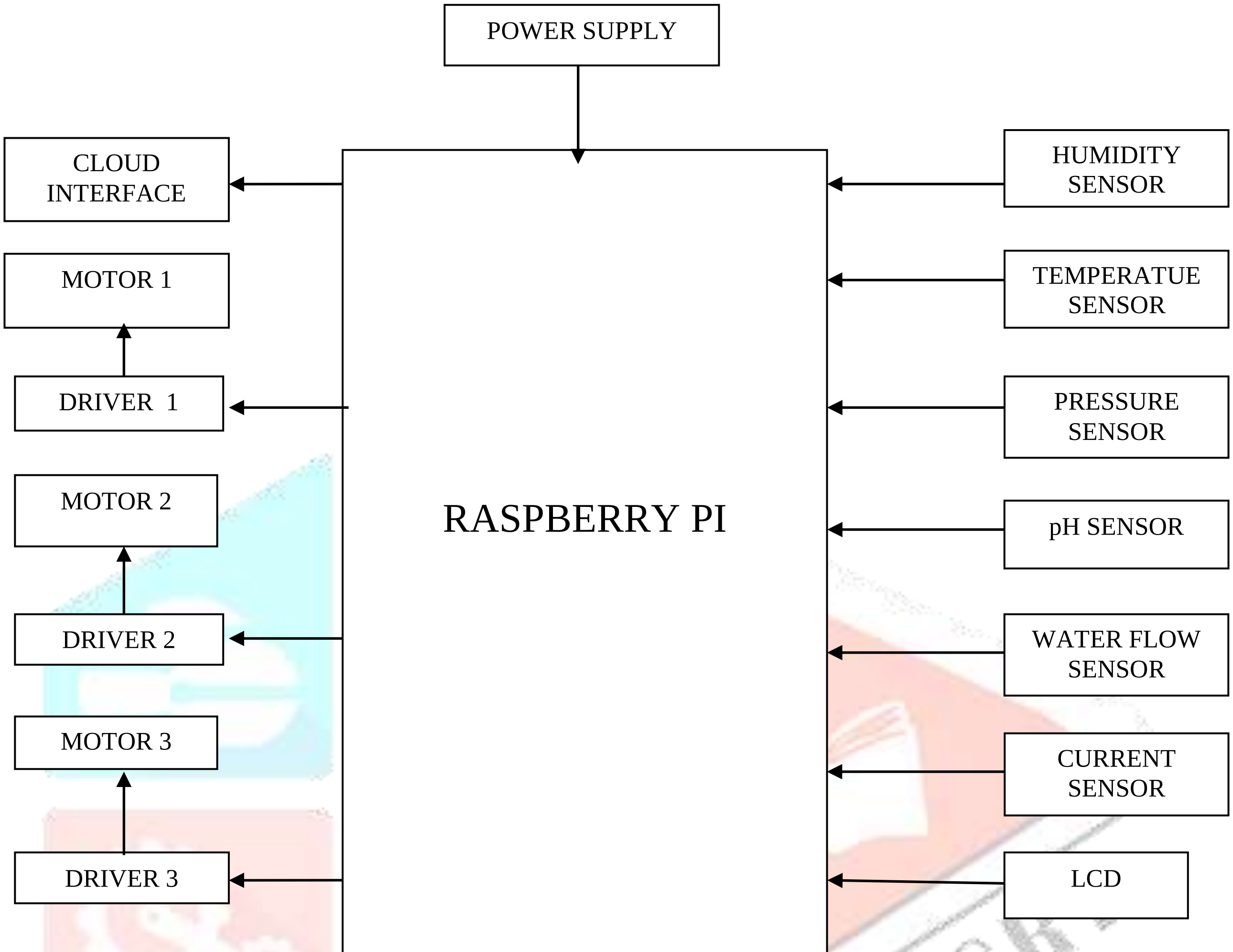


Fig. 4. Light intensity sensor signal conditioning circuit design.

III. Proposed System



Cloud Infrastructure Management Interface (CIMI)

CIMI addresses the management of the lifecycle of infrastructure provided by a Provider (cloud server). CIMI does not extend beyond infrastructure management to the control of the applications and services that the Consumer (cloud client) chooses to run on the infrastructure provided as a service by the Provider. CIMI allows interoperability between a Consumer and multiple Providers that all offer the standard CIMI interface for managing a cloud infrastructure.

The interface uses the Hyper Text Transfer Protocol (HTTP) to send and receive messages that are formatted using either Java Script Object Notation (JSON) or the eXtensible Markup Language (XML). CIMI uses a convention called Representational State Transfer (REST) as the basis for the operations that are standardized through this interface. REST is a set of principles first proposed in a Phd. thesis by Roy Fielding and is as an alternative to SOAP-based web services protocols. CIMI models the kinds of resources that are typically available in an infrastructure cloud and represents each resource with a set of key/value pairs of various types such as Boolean, date time, duration, integer, string, ref, map, structure, array, collection.

These key/value pairs represent aspects of the resource's management such as configuration of the resource, operations on the resource, instrumentation of the resource metrics and relationships between resources. The architecture of a typical cloud deployment explains the application of various standards in the appropriate places. Figure 1 shows the various elements of an infrastructure cloud deployment and the actors. The Hypervisor, Virtual Machine (VM), Operating System (OS), and Applications/Services as well as underlying resources are shown being orchestrated (pooled and provisioned) by the IaaS API implementation as well as being managed through Systems Management.

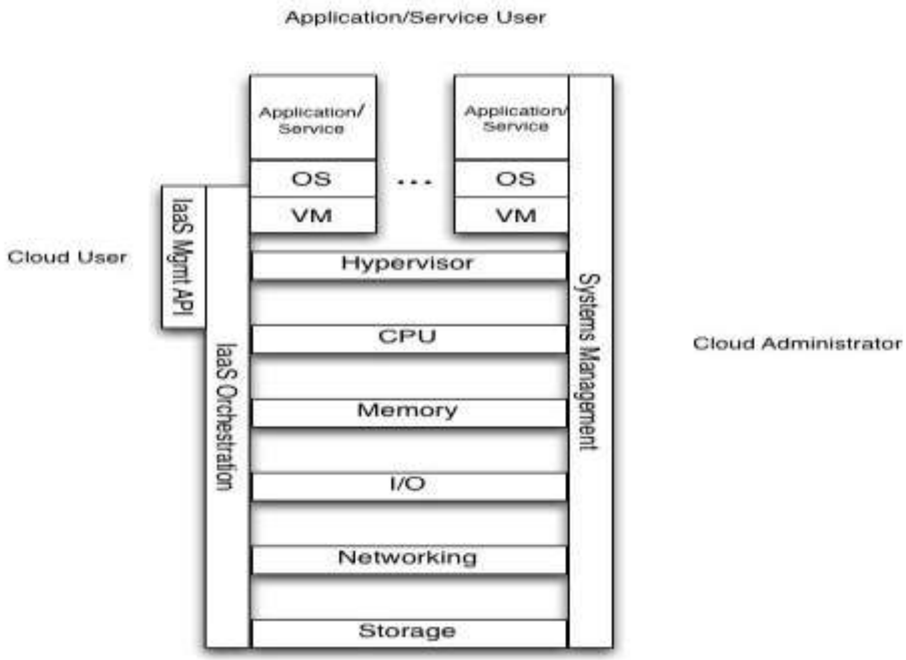


Fig.5. Infrastructure Cloud Elements and Actors

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IV. HARDWARE

Humidity Sensor

Humidity is the presence of water in air. The amount of water vapor in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapor also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, **humidity sensing** is very important, especially in the control systems for industrial processes and human comfort.

Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. In semiconductor industry, humidity or moisture levels needs to be properly controlled & monitored during wafer processing. In medical applications, humidity control is required for respiratory equipments, sterilizers, incubators, pharmaceutical processing, and biological products. Humidity control is also necessary in chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. In agriculture, measurement of humidity is important for plantation protection (dew prevention), soil moisture monitoring, etc. For domestic applications, humidity control is required for living environment in buildings, cooking control for microwave ovens, etc. In all such applications and many others, **humidity sensors** are employed to provide an indication of the moisture levels in the environment.

Sensing Principle

Humidity measurement can be done using dry and wet bulb hygrometers, dew point hygrometers, and electronic hygrometers. There has been a surge in the demand of electronic hygrometers, often called humidity sensors. Electronic type hygrometers or humidity sensors can be broadly divided into two categories: one employs capacitive sensing principle, while other use resistive effects. Humidity sensors relying on this principle consists of a hygroscopic dielectric material sandwiched between a pair of electrodes forming a small capacitor. Most capacitive sensors use a plastic or polymer as the dielectric material, with a typical dielectric constant ranging from 2 to 15. In absence of moisture, the dielectric constant of the hygroscopic dielectric material and the sensor geometry determine the value of capacitance.

At normal room temperature, the dielectric constant of water vapor has a value of about 80, a value much larger than the constant of the sensor dielectric material. Therefore, absorption of water vapor by the sensor results in an increase in sensor capacitance.At equilibrium conditions, the amount of moisture present in a hygroscopic material depends on both the ambient temperature and the ambient water vapor pressure. This is true also for the hygroscopic dielectric material used on the sensor.

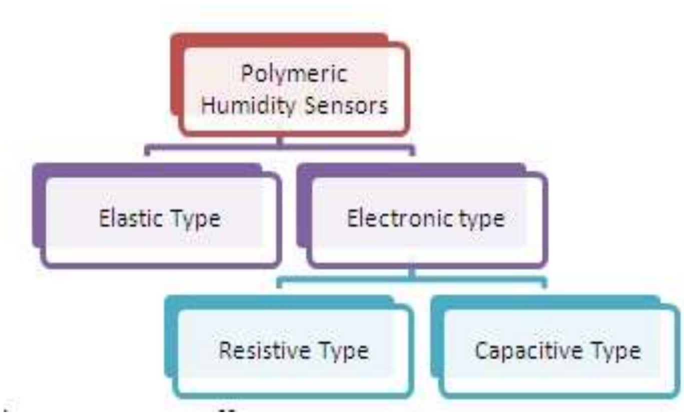

Fig.6.Sensing Principle

By definition, relative humidity is a function of both the ambient temperature and water vapor pressure. Therefore there is a relationship between relative humidity, the amount of moisture present in the sensor, and sensor capacitance. This relationship governs the operation of a capacitive humidity instrument.

Temperature Sensor

A temperature sensor is a device, usually an RTD (resistance temperature detector) or a thermocouple, that collects the data about temperature from a particular source and converts the data into understandable form for a device or an observer. Temperature sensors are used in many applications like HV and AC system environmental controls, food processing units, medical devices, chemical handling and automotive under the hood monitoring and controlling systems, etc. The most common type of temperature sensor is a thermometer, which is used to measure temperature of solids, liquids and gases. It is also a common type of temperature sensor mostly used for non-scientific purposes because it is not so accurate.

Pressure Sensor

A **pressure sensor** is a device for pressure measurement of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. For the purposes of this article, such a signal is electrical.

Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called pressure transducers, pressure transmitters, pressure senders, pressure indicators, piezometers and manometers, among other names.

Pressure sensors can vary drastically in technology, design, performance, application suitability and cost. A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide. There is also a category of pressure sensors that are designed to measure in a dynamic mode for capturing very high speed changes in pressure. These sensors are commonly manufactured out of piezoelectric materials such as quartz.

Water Flow Sensor

Water Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area. For very large flows, tracer methods may be used to deduce the flow rate from the change in concentration of a dye or radioisotope.

Current transformer

Current transformer (CT) is used for measurement of electric currents. Current transformers, together with voltage transformers (VT) (potential transformers (PT)), are known as instrument transformers. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays in the electrical power industry.

Raspberry Pi

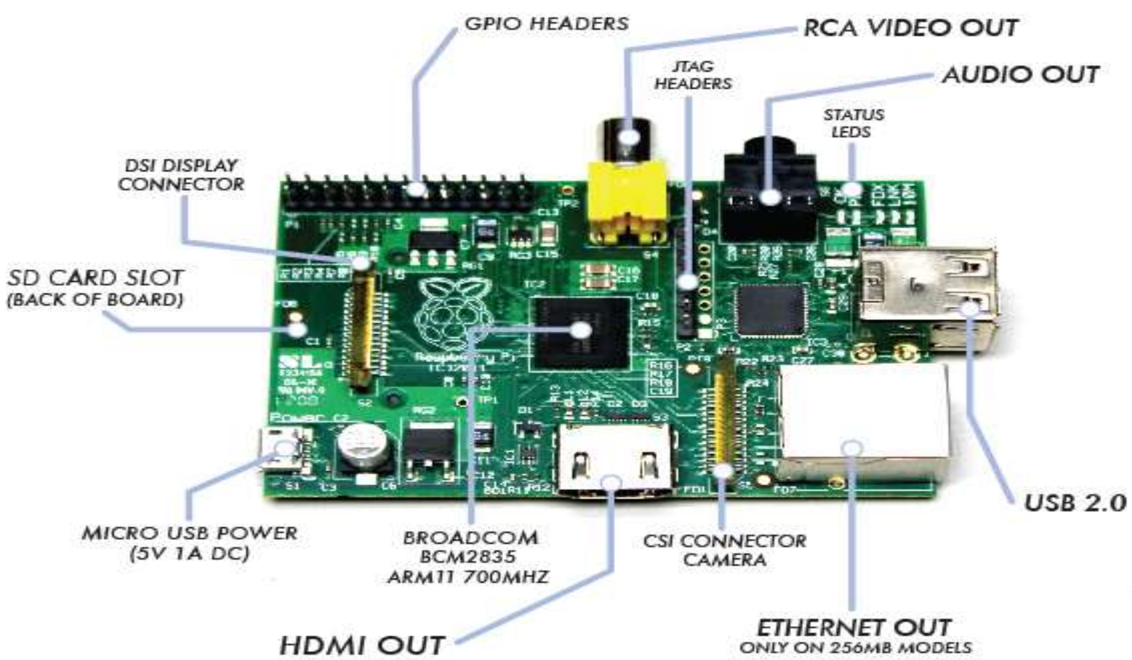

Fig.7.Raspberry Pi

The Raspberry Pi is a series of small single-board computers. Processor speed ranges from 700 MHz to 1.2 GHz for the Pi 3; on-board memory ranges from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either SDHC or MicroSDHC sizes. The boards have one to four USB ports. For video output, HDMI and composite video are supported, with a standard 3.5 mm phono jack for audio output. Lower-level output is provided by a number of GPIO pins which support common protocols like I²C.

The Raspberry Pi 3, with a quad-core ARM Cortex-A53 processor, is described as 10 times the performance of a Raspberry Pi 1. Most Raspberry Pi chips could be overclocked to 800 MHz, and some to 1000 MHz. There are reports the Raspberry Pi 2 can be similarly overclocked, in extreme cases, even to 1500 MHz (discarding all safety features and over-voltage limitations).

V.RESULT AND DISCUSSION

Temperature Sensor Test Result

The result from temperature and humidity sensor experiment indicate that the temperature sensor. A testing in order to validate and calibrate the readings of the sensor was done by implementing other digital temperature reader which has a known tolerance and reliability. The sensor's value is still within its tolerable range.

Parameter	**Designed circuit**	**Reference unit**
Average Temperature	28.5	27.1

pH Meter Test Result

A pH meter is tested using nutrient water mixture for aeroponics. The pH level reading is consistent between 6.2 – 6.7 (neutral value). This results indicate that the sensor works consistently for aeroponics application.

Time (minutes)	pH Value
0	6.5
10	6.1
20	6.25
30	6.7
40	6.5
50	6.4
60	6.2

Connect Pi to the network

Fig.8.Connect Pi to the network

VI. CONCLUSION

This system will be effective when implemented in the aeroponics agriculture. Delivers nutrients directly to the plant roots. Completely programmable technology conserves energy. Closed-loop system conserves water. Conserves water through runoff absorption into roots. Can be combined with hydroponics. Crops are easier to harvest in the absence of soil. Higher density crops optimizes output. Reduce labor cost through automation. Produces higher quality food in a controlled environment. Reduced risk of disease and pest infestation in a controlled environment. No need to immerse immerse roots in water which offers more control. Roots are provided with better exposure to oxygen. Scalable systems can range from commercial level to apartment-sized gardens. Produces more food with less effort. This can be developed in future for better results. There are many chances for developing system in future which would be of great development in the field of aeroponics. Thus this product the better development in present and with certain other development in future.

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