Extensible Embedded Web Server for Online Farming

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Abstract— The advanced development in embedded system and web server can be integrated to erect a farm in fully automatic and technical method. The new ideas and technologies are used in the farm sector of the country to effectively utilize the available land resources. All farm parameters are measures using new technologies, using the threshold values decision is taken and the requirements are notified to the user using the web server. Sensor array is used to monitor the farm parameters and microcontroller is used for controlling purposes. The aim of this paper is to improve the productivity of the crop with low investment and also helps the farmer to produce the proper crop. The farmer can optimize the water usage, using the soil analysis, fertilizer usage amount is also reduced significantly. Wireless IP camera is used to feed live video of the farm. Using the Web server the farmer can view the farm status from anywhere in the world. this system has potential to attract the entrepreneurs to invest the farm sector also cultivate in geographically isolated areas.

Index Terms— Agriculture, Arduino, Microcontroller, Online farming, Sensor array, Soil analysis, Web Server

1 Introduction

In a country like India, agriculture is the main occupation and the major economy is also based on agriculture. The climatic conditions are isotropic, still we are not able to make full use of agricultural resources. The various reasons are lack of rain, change in atmospheric conditions, and unplanned use of water. Another important reason is the lack of knowledge related to soil analysis and pH level for the growth of crops. Agriculture uses 85% of the water resources worldwide, and this percentage will continue to be dominant in water consumption because of population growth and increased food demand. In the modern drip irrigation systems, the most significant advantage is that water is supplied near the root zone of the plants drip by drip due to which a large quantity of water is saved. At the present era, the farmers have been using irrigation technique in India through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. The other side of the coin is the fertilizers overdosing which threatens food safety and deteriorates the quality of soil. This is caused by the farmers not always being aware of the detailed updated soil content analysis. Also, the existing fertilizing machines do not allow farmers to adjust the dozing of fertilizers "on-line" depending on the actual chemical contents of each specific part of the field.

Plants must obtain the elements essential for their growth and these essential elements are called nutrients. Those needed in the greatest amount are called macronutrients whereas those needed in lesser amounts are called micronutrients. Among the macronutrients are nitrogen, phosphorus, and potassium. These three elements are those most rapidly removed from the soil by plants. Therefore, many commercial plant fertilizers supply these three essential elements. The amount of each element is indicated by N-P-K numbers. The analysis information at right (taken from a package of garden fertilizer) shows an N-P-K rating of 15-30-15. These numbers indicate the percent by weight of nitrogen, diphosphorus pentoxide, and potassium oxide in the fertilizer. The 15-30-15 rating indicates that 15% by weight of the fertilizer is nitrogen (N). It also indicates that the weight of phosphorus in the fertilizer is the same as it would be if the fertilizer contained 30% diphosphorus pentoxide (P_2O_5). The amount of potassium in the fertilizer is the same as it would be if the fertilizer were 15% potassium oxide (K_2O).

Soil testing can save you money by identifying what parts of your farm have low fertility and need extra fertilizer to improve productivity. Soils with higher fertility need less fertilizer. It will also help to plan fertilizer, slurry and manure spreading. Applications of the wrong fertilizer grade and, or in the incorrect amount, can be harmful to the environment, or lead to a yield loss hurting the farm's profitability. Correct fertilizer calculations are as important to plant fertility and making sure that the fertilizer spreader is properly calibrated. Soil testing will help to determine the proper application rates of lime or sulphur to adjust soil pH and the current availability of nutrients in the root zone. If the proper pH value is not maintained, the nutrients cannot be absorbed by the soil. Soil tests can help farmers avoid over application of expensive nutrients. The soil test report will show a "lime requirement" result to indicate the rate of lime required to increase the soil pH to the correct level. Optimum pH for grassland is 6.2 to 6.5.

The new ideas and modern technologies are used in the farm sector of the country to effectively utilize the available land resources. In the modern drip irrigation systems, the most significant advantage is that water is supplied near the

root zone of the plants drip by drip due to which a large quantity of water is saved. At the present era, the farmers have been using irrigation technique in India through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. A data acquisition system was deployed for monitoring crop conditions by means of soil moisture and soil, air, and canopy temperature measurement in cropped fields. Data were downloaded using a handheld computer connected via a serial
port for analysis and storage [1]. Another system used to achieve the effectiveness of water management was developed
based on a WSN and a weather station for Internet monitoring of drainage water using distributed passive capillary wick-type
lysimeters. Water flux leached below the root zone under an irrigated cropping system was measured [2]. There are hybrid architectures, wireless modules are located inside the greenhouse where great flexibility is required, and wired modules are used in the outside area as actuator controllers [3].

Power management has been addressed in both hardware and software with new electronic designs and operation techniques. The selection of a microprocessor becomes important in power aware design. Modern CMOS and micro-electro-mechanical systems (MEMS) technologies allowed manufacturers to produce on average every three years a enhance generation of circuits by integrating sensors, signal conditioning, signal processing, digital output options, communications, and power supply units [4], [5]. Energy harvesting mechanisms have been employed, in cases where it is difficult for changing or recharging batteries, hence this strategy has involved combining it with efficient power management algorithms to optimize battery lifetime. Power harvesting is a complementary approach that depends on ambient energy sources, including environmental vibration, human power, thermal, solar, and wind that can be converted into useable electrical energy [6]–[8].

In this paper, the development of the deployment of an automated agriculture based on microcontrollers and web server in geographical areas is presented. The aim of the implementation was to demonstrate that the automated agriculture can be used to reduce the cost investment and increase the profit. The implementation is a photovoltaic powered automated agriculture that consists of a sensor array which is deployed in the root zones of the plants. The Internet connection allows the data inspection in real time on a web server, where the farm parameters are graphically displayed through an application interface and stored in a database server. Because of its mobility, the farmer can monitor and control the farm from anywhere using the web server.

2. System Design and Implementation

In recent years, many new ideas and technologies are developed in the field of agriculture. The automated agriculture system hereby reported usually operated in two modes as shown in Fig. 1, microcontroller based system and web server based system. The two modes come under the control of same microcontroller and the required mode is selected using the mode selection switch. The mode selection switch is available in the farm and also in the web server.

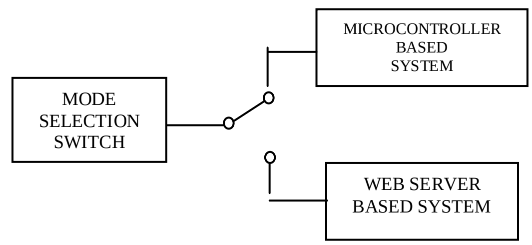

Fig.1. Mode selection

. The farmer can select the mode either by manually using the mode selection switch in the farm or logging into the web server. Only one mode is active at a time and two modes can be switched off after the crop cultivation.

2.1 Microcontroller based system

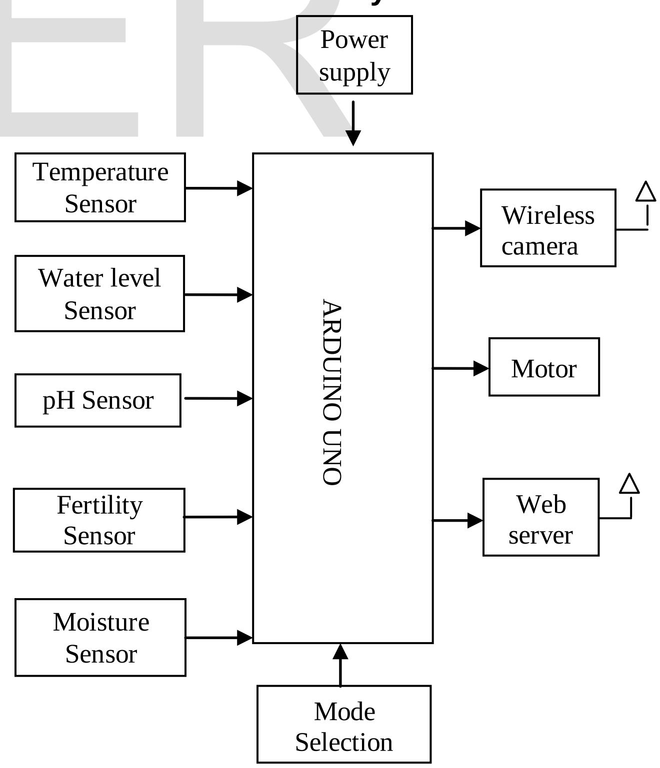

Fig.2. Microcontroller based system

A microcontroller based system was selected by the user using the mode selection switch. The system consists of a sensor array, Arduino Uno board with microcontroller, power supply and motor driver as shown in Fig 2.This system may have a rechargeable battery with the solar panel as its source supply. This solar panel produces the required voltage and recharges the battery. Sensor array measures the farm parameters and signal conditioning unit performs necessary operations. Based on the threshold values, the microcontroller decides and performs the operation. The decision is notified to the farmer and the farmer can view the farm status through the web server. Wireless IP is used to feed live video of the farm status in the web server [9].

1) ARDUINO UNO: The Arduino Uno is a microcontroller board based on the ATmega328 microcontroller. It consists of 14 digital input/output pins,6 analog input pins, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The ATMEGA chip is removable from the board. This is especially useful the processor is fried and need to replace it, use the board alone as a USB to serial interface. R3 of the Uno adds two new pins on the digital side: SDA and SCL. It contains everything needed to support the microcontroller by simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and V_{in} pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library.

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. TheATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2Cbus. The Arduino Uno can be programmed with the Arduino software. Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100nF capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well coordinated with the start of the upload.

2) Sensor array: The sensor array consists of temperature sensor, soil moisture sensor, water level sensor, pH sensor and fertility sensor are used. The temperature sensor measures the temperature of the farm. The temperature sensor Calibrated directly in degree Celsius (Centigrade) with 0.5°C accuracy guarantee (at +25°C). It is rated for −55° to +150°C range and suitable for remote applications. Low cost and it operates from 4 to 30V.

Soil moisture sensor measures the moisture level of the farm. The two copper leads act as the sensor probes. They are immersed into the specimen soil whose moisture content is under test. Based on the measurements, the microcontroller compares the measured values with the threshold value. If the threshold value exceeds, the microcontroller automatically switches ON the motor. Water level sensor is used to measures the water level in the farm. It is rugged and fully submersible. It is available with alarm for water or air contact. It is ideal for water spills, tank failure, pump failure, rising water, and floods. This is used to identify the motor failure and the failure is notified to the farmer through web server. pH sensor measures the pH value of the farm. pH range lies between 0 to 14. It is used for measuring the pH (acidity or alkalinity) of a liquid. pH sensor consists of a special measuring probe (a glass electrode) and reference electrode (H electrode). The electrode length is 16mm and the electrode diameter is 12mm approximately. Fertility sensor measures the fertility level of the farm. It measures the NPK values of the farm. Based on these values, the farmer can supply the required fertilizer to the soil.

3) Photovoltaic Cell: To maintain the charge of the batteries, a solar panel MPT4.8-75 was employed. Each solar panel delivers 50mA at 4.8V, which is sufficient energy to maintain the voltage of the three rechargeable batteries. A MSS1P2U Schottky diode (Vishay, Shelton, CT) is used to prevent the solar module and to drain the battery when is in the dark. The solar panel is encapsulated in a 3-mm clear polyester that is fastened in the upper part of a PVC pole allowing for the correct alignment of the photovoltaic panel to the sun. The stick is 50 cm of length and 12.5 mm of diameter; the lower end of the pole had a tip end to be buried.

4) Wireless IP camera: Wireless IP is used to feed live video of the farm status in the web server. An Internet protocol camera, or IP camera, is a type of digital video camera commonly employed for surveillance, and which unlike analog closed circuit television (CCTV) cameras can send and receive data via a computer network and the Internet. IP cameras are able to function on a wireless network. It uses Ultra Wide Angle Lens and Wireless Transmission distance is up to 1350 Feet. It has Infrared Capability for Ultra Low Light. The transmission of commands for PTZ (pan, tilt, zoom) cameras via a single network cable. Modern IP cameras have the ability to operate without an additional power supply. They can work with the PoE (Power over Ethernet) protocol which gives power via the Ethernet cable.

2.2 Web server based system

Another mode in automated agriculture is web server based system which is selected using mode selection switch. This mode is more similar to the previous mode; the difference is that the farmer will decide the operation to be performed not by the microcontroller. The farmer can view the current status of the farm through the web server from any part of the world. The microcontroller measures the farm parameters and loads the data to the web server via internet. The information is stored in the web server database. The farmer access the web server using the remote devices. Using the remote devices (smart phones, laptops, tablets, etc), the farmer can monitor and control the farm parameters from any part of the world. The wireless IP camera feed live video of farm

This system consists of sensors, microcontroller, Ethernet, web server and remote devices as shown in Fig 3.The farmer access the web server via internet.

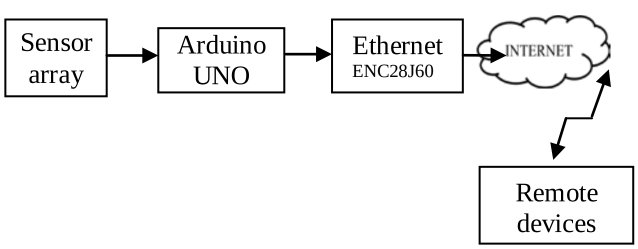

Fig.3. Web server based system

1) ENC28J60Ethernet: The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It is designed to serve as an Ethernet network interface for any controller equipped with SPI. The ENC28J60 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols. Communication with the host controller is implemented via an interrupt pin I SPI, with clock rates of up to 20MHz. Two dedicated pins are used for LED link and network activity indication.

With the ENC28J60, two pulse transformers and a few passive components are all that is required to connect a microcontroller to an Ethernet network. This is a driver for Ethernet controller chip which maintains communication between node and the network. It provides the routines to transmit IP frame onto the network or vice versa.

The ENC28J60 consists of seven major functional blocks:

1. An SPI interface that serves as a communication channel between the host controller and theENC28J60.
2. Control Registers which are used to control and monitor the ENC28J60.
3. A dual port RAM buffer for received and transmitted data packets.
4. An arbiter to control the access to the RAM buffer when requests are made from DMA, transmit and receive blocks.
5. The bus interface that interprets data and commands received via the SPI interface.
6. The MAC (Medium Access Control) module that implements IEEE 802.3 compliant MAC logic.
7. The PHY (Physical Layer) module that encodes and decodes the analog data that is present I twisted pair interface.

The device also contains other support blocks, such I oscillator, on-chip voltage regulator, level translators to provide 5V tolerant I/Os and system control logic.

2) Acquisition terminal: Acquisition terminal program gets RF data through a serial port, USB port, then temporarily stores in local, can be checked conveniently. There are monitoring and controlling that maps and historical data query functions. In the specified operating or provisions specified duration, acquisition terminal will upload data to a WEB database server.

3) Web Data base server: Web data base server, being responsible for receiving all the acquisition terminal (regional) data, and according to the area code, sets all data in the database. Then it provides a WEB server functions. System user can visit the data anytime through specific terminal server.

3. SOFTWARE DESIGN

Software design approach for automated agriculture is based on two parts, first is microcontroller programming, GUI design in VB results obtained from base module. Detailed flowchart for the working of whole system as well as software design is shown in figure 4.

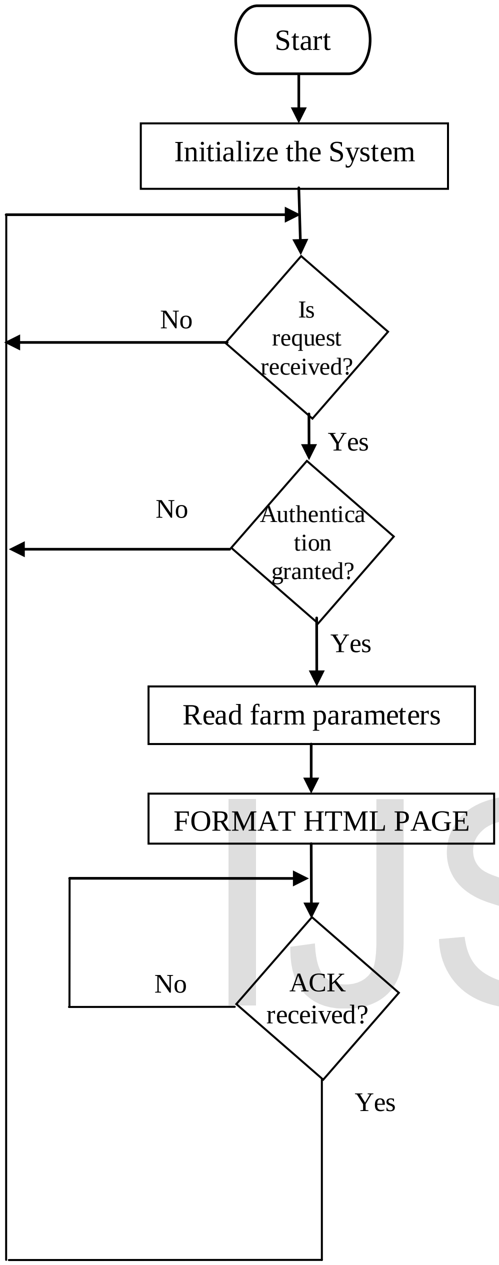

Fig.4. Flow chart of the system

I. **4. Results**

The output window is shown in Fig 5. It consists of mode selection switch to select any one of the modes based on the user requirement. Motor status allows the user to monitor and control the motor. Motor can be switched ON or OFF directly by the user. The user can view the current status of the farm through the online streaming of the video in the screen. Various farm parameter values, date and time are also displayed on the screen. From the soil moisture and temperature value, the farmer can switch ON or OFF the motor. Using pH level and NPK value, suitable crop and amount of fertilizer is also determined. Water level is used to detect motor failure.

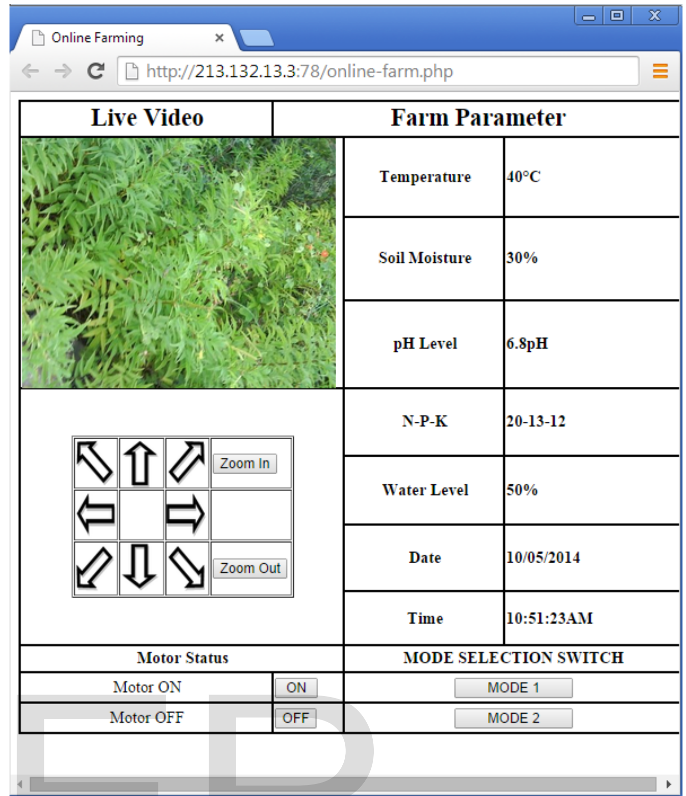

Fig. 5.Output window

5. Conclusion

In this paper, we have proposed automated agriculture system to erect a farm in the technical manner. Employing the web server module, the farmer can monitor and control the farm in a simple manner. The proposed system is well suited for farmer to invest in geographically isolated areas. The automated agriculture system implemented was found to be feasible and cost effective for optimizing water resources, reduction in fertilizer cost for agricultural production. The automated agriculture system developed proves that the low investment in agriculture leads to better productivity. Furthermore, the Internet and wireless IP camera allows the supervision and control the farm through mobile telecommunication devices, such as a Smartphone. Besides the monetary savings in water use and fertilizers, the importance of the preservation of this natural resource justifies the use of this kind of automated agriculture systems.

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