Indirect Crop Monitoring using Sensors & Mobile Camera

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Abstract— With the fast growing technology and new inventions in science to make life easy for humans; this paper introduces a method to gather the information about the present situation of a crop field from a remote place. The information providing device consists of an automatic tracking solar panel, a microcontroller, sensors, battery and Wi-Fi module. A mobile camera is set up in the field to obtain the visual information about the field.

Key words: Indirect Crop Monitoring, Sensors, Mobile Camera

I. Introduction

Due to the lack of accuracy; environmental factors such as soil irrigation and illumination intensity cannot get scientific and timely management, which leads to obstruction to the growth of crops and makes diseases and pests more and more serious on it. Therefore, acquisition and a timely delivery of the information of the paddy fields have become a basic link to ensure the quality of crops; A wireless sensor monitoring node is presented for monitoring the crops without direct inspection. In this node, the parameters such as soil moisture, temperature, humidity, pH sensitivity, light intensity are collected from the field. A mobile camera is setup for visually monitoring the growth of the crops in the field. The data obtained from the sensors are collected by the microcontroller which is then sent to the host computer. Data transmission takes place through the Wifi and GPRS module to the host computer. The host computer saves the data packages for further analysis. Real-time data is updated every six seconds. The battery is charged by the solar panel and hence the device can work during night time as well as in the absence of light. In addition to this, the automatic tracking function of solar panel makes it possible to move the solar panel following the sun to achieve the maximum efficiency. This technique is an effective way to improve the precision of agriculture. The result of this experiment can prove that, we can obtain the data of the condition of the field without self-inspection on the field, accurate transmission of data to the desired location and the solar power supply system can meet the demand for power requirement in the field during continuous rainy days.

II. Literature Survey

A multi-parameters monitoring system based on wireless network was set up to achieve remote real-time monitoring of aquaculture water quality, in order to improve the quality of aquaculture products and solve such problems as being difficult in wiring and high costs in current monitoring system. In the system solar cells and lithium cells were used for power supply. The YCS-2000 dissolved oxygen sensor, pH electrode, Pt1000 temperature sensor and ammonia nitrogen sensor were used to monitor the parameters of aquaculture water quality; STM32F103 chip was used for data processing; Zigbee and GPRS modules were used for data transmission to the remote monitoring center, where the data were stored and displayed. The system was connected with aerator to realize automatic control of dissolved oxygen concentration. The test results showed high confidence level of data transmission with a packet loss rate of 0.43%.

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Recent changes in rice crop management within Northern Italy rice district led to a reduction of seeding in flooding condition, which may have an impact on reservoir water management and on the animal and plant communities that depend on the flooded paddies. Therefore, monitoring and quantifying the spatial and temporal variability of water presence in paddy fields is becoming important. In this study we present a method to estimate dynamics of presence of standing water (i.e. fraction of flooded area) in rice fields using MODIS data. First, we produced high resolution water presence maps from Landsat by thresholding the Normalised Difference Flood Index (NDFI) made: we made it by comparing five Landsat 8 images with field-obtained information about rice field status and water presence. Using these data we developed an empirical model to estimate the flooding fraction of each MODIS cell. Finally we validated the MODIS-based flooding maps with both Landsat and ground information. Results showed a good predictability of water surface from Landsat (OA = 92%) and a robust usability of MODIS data to predict water fraction ($R^2 = 0.73$, EF = 0.57, RMSE = 0.13 at 1 × 1 km resolution). Analysis showed that the predictive ability of the model decreases with the greening up of rice, so we used NDVI to automatically discriminate estimations for inaccurate cells in order to provide the water maps with a reliability flag. Results demonstrate that it is possible to monitor water dynamics in rice paddies using moderate resolution multispectral satellite data. The achievement is a proof of concept for the analysis of MODIS archives to investigate irrigation dynamics in the last 15 years to retrieve information for ecological and hydrological studies.

Leaf area index (LAI) is a key biophysical parameter used to determine foliage cover and crop growth in environmental studies in order to assess crop yield. Frequently, plant canopy analyzers (LAI-2000) and digital cameras for hemispherical photography (DHP) are used for indirect effective plant area index (PAI_{eff}) estimates. Nevertheless, these instruments are expensive and have the disadvantages of low portability and maintenance. Recently, a smartphone app called PocketLAI was presented and tested for acquiring PAI_{eff}measurements. It was used during an entire rice season for indirect PAI_{eff} estimations and for deriving reference high-resolution PAI_{eff} maps. Ground PAI_{eff} values acquired with PocketLAI, LAI-2000, and DHP were well correlated (R^2 = 0.95, RMSE = 0.21 m^2/m^2 for Licor-2000, and R^2 = 0.94, RMSE = 0.6 m^2/m^2 for DHP). Complementary data such as phenology and leaf chlorophyll content were acquired to complement seasonal rice plant information provided by PAI_{eff}. High-resolution PAI_{eff} maps, which can be used for the validation of remote sensing products, have been derived using a global transfer function (TF) made of several measuring dates and their associated satellite radiances.

The cultivation of rice, one of the most important staple crops worldwide, has very high water requirements. A variety of irrigation practices are applied, whose pros and cons, both in terms of water productivity and of their effects on the environment, are not completely understood yet. The continuous monitoring of irrigation and rainfall inputs, as well as of soil water dynamics, is a very important factor in the analysis of these practices. At the same time, however, it represents a challenging and costly task because of the complexity of the processes involved, of the difference in nature and magnitude of the driving variables and of the high variety of field conditions. In this paper, we present the prototype of an integrated, multisensor system for the continuous monitoring of water dynamics in rice fields under different irrigation regimes. The system consists of the following: (1) flow measurement devices for the monitoring of irrigation supply and tailwater drainage; (2) piezometers for groundwater level monitoring; (3) level gauges for monitoring the flooding depth; (4) multilevel tensiometers and moisture sensor clusters to monitor soil water status; (5) eddy covariance station for the estimation of evapotranspiration fluxes

(6) wireless transmission devices and software interface for data transfer, storage and control from remote computer. The system is modular and it is replicable in different field conditions. It was successfully applied over a 2-year period in three experimental plots in Northern Italy, each one with a different water management strategy. In the paper, we present information concerning the different instruments selected, their interconnections and their integration in a common remote control scheme. We also provide considerations and figures on the material and labour costs of the installation and management of the system.

III. WORKING

This system has four sections which are sensors, single board computer, solar tracking system and a net based communication system. The microcontroller collects the data from the sensors. Then it divide the data for two purposes. One is used for solar tracking and other set of data will be packed and send to a remote computer through the network. The embedded unit is based on Arduino Mega2560 a Single Board Computer. The features like hardware interfaces (PWM, communication, Digital, Analog),the required in built memory space, ready to use structure, large library supported IDE and instant programmability makes Arduino Mega2560 suitable for this system. The digital /PWM pins are used to control the motor for solar tracking. The ADC pins are used to take analog signals from light sensors. The temperature sensor used here uses its own 1 wire protocol so it can be connected to any GPIO pin. Finally the WiFi is interfaced to the UART pins.

Two light sensors are used to sense the solar light intensity. LDRs are used to sense the light. The variation of resistance due to the change in the light intensity varies the voltage across the LDR. Microcontroller reads the analog variation of voltage through the ADC pin. The average lux value of two sensors gives the light intensity data. The ADC value of each sensor decides the angular position in east – west direction of solar panel.

The WiFi module is interfaced to the UART port of Arduino Mega2560. Initially SBC configures the WiFi module. There after SBC sends web page which contains sensor data as a replay to the request from the remote computer.

The solar tracking system uses a motor to rotate the panel to optimise availability of solar light on the panel. According to the light sensor data SBC sends control signals to the motor through driver circuit. The driver circuit amplifies the ampere and voltage of the control signal from SBC to motor. The power supply unit has four sections. A solar panel, charger, battery and regulator. The panel generate voltage to charge the battery. The charger circuit manages the charging process. The battery stores the charge from the panel and deliver the charge for the other circuit sections. The regulator circuit regulates the voltage to 12V, 5V and 3.3V.The motor uses 12V, WiFi module uses 3.3V and other circuit sections uses 5V.

IV. HARDWARE

A. Microcontroller

The Arduino Mega 2560 is a microcontroller board based on the AT mega 2560.It is widely used in the application of embedded systems because of its high performance, low cost and low power consumption. It has 54 digital input/output pins (of which 14 can be used as PWM output pins), 16 analog inputs, 4UARTS (a hardware serial port), a 16 Mhz crystal oscillator, a USB connection, power jack,a n ICSP header, and a reset button. It contain everything needed to support the microcontroller, simply connect it to a computer with USB cable or power it with a AC-DC adapter or battery to get started. The AT mega 2560 has 256 KB of flash memory for storing code,8 KB of SRAM and 4 KB of

EEPROM. It operates at 5v.AT mega 2560 provides four hardware UARTS for TTL serial communication. The arduino mega can be programmed with arduino software. Each of the 54 digital pin can be used as an input/output pin using pinmode(),digital write(),digital read() functions. They operate at 5v.Each pin can provide or receive a maximum of 40 Ma and has an internal pull up resistor of 20-50 kohms.

B. Sensors

There are three type of sensors in this node; temperature, light and humidity sensor.DHT11 digital temperature and humidity sensor is a composite senor contains calibrated digital signal output of the temperature and humidity. The temperature sensor used here uses it's own one wire protocol. It uses single wire bidirectional serial communication. Data length of transmission is 40 bits. The sensor incudes a resistive sense of wet components and an NTC temperature measurement device and connected with a8-bit microcontroller. Two light sensors are used to sense the solar light intensity. LDRs are used to sense the light. Microcontroller reads analog variation of voltage through ADC pin. The average lux value of two sensors gives light intensity data. ADC value determines the position in east-west direction of solar panel. The resistance of photoresistor decreases with increasing incident light intensity. It obtains more accurate numerical value after processing.

C. Wi-FI Module

We use ESP8266 Wifi module for data transmission. The wifi module is interfaced to UART port of Arduino 2560.SBC configure wifi module.ESP8266 module can operate in the low power connectivity modes.

The module can also integrate an SPI flash of 16Mbits used for storing user programs, data and firmware. The ESP8266 Wifi module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wifi network. Each ESP8266 module comes pre-programmed with an AT command set firmware. The ESP module is extremely cost effective board with a huge and ever growing community. Here, the SBC send web page which contain sensor data as a replay to the request from the host remote computer

D. Automatic Tracking Solar Power Supply System

To maximize the efficiency of solar energy conversion, the function of automatic tracking of solar panel is presented in this design. Generally the methods of fixed time assay and coordinates have been widely used which have been implemented to realize the tracking. Solar tracking system consist of solar panel and motor driver circuit. Solar tracking system uses the motor to rotate the panel. According to the light sensor data SBC send control signal to the motor through driver circuit. Compared with placing the two light sensors in parallel on the lower end of solar cell panel, it can make greater numerical difference between the two light sensors to put them together at a certain angle in the same position on the lower end of the solar cell panel. So solar cell panel is more sensitive to the change of solar altitude. When sunlight irradiates vertically on the surface of solar cell panel, if the numerical differences of the data received from the two light intensity sensors are very small, then the motor does not rotate. Therefore, the control is more accurate and the circuit is relatively easy to be achieved.

E. Mobile Camera

Camera phone allows automatic photo sharing .There is no need for cable or removable media to connect to a personal computer. A camera phone is a mobile phone which is able to capture photographs and often record video using one or more built in digital camera. Most camera phones are simpler than separate digital camera. Photo flash is typically provided by an LED source which illuminates less intensely over a much longer exposure time than a bright and near instantaneous flash strobe. Near all camera phone use CMOS image sensor due to largely reduced power consumption compared to CCD type cameras, which are also used but in few camera phones

V. SOFTWARE

```
#define DEBUG true
 #include "dht.h"
 #define dht_apin A0 // Analog Pin sensor is connected to
 dht DHT;
 int EAST;
 int WEST;
 int temp;
 int humid;
 float lux;
 float lux1;
 float lux2;
 float lux_volt;
 #define SLREST A1
 #define SLRWST A2
 #define M1 5
 #define M2 6
 int cnt;
 int cnt1;
 int connectionId;
void setup()
{
  Serial.begin(115200);    //////For Serial monitor
  Serial3.begin(115200); //////ESP Baud rate
  sendData("AT+RST\r\n",2000,DEBUG); // reset module
  sendData("AT+CWMODE=2\r\n",1000,DEBUG);           //
configure as access point
  sendData("AT+CIFSR\r\n",1000,DEBUG); // get ip address
  sendData("AT+CIPMUX=1\r\n",1000,DEBUG);            //
configure for multiple connections
  sendData("AT+CIPSERVER=1,80\r\n",1000,DEBUG);   //
turn on server on port 80
  pinMode(M1, OUTPUT);
  pinMode(M2, OUTPUT);
  digitalWrite(M2, LOW);
  digitalWrite(M1, LOW);
  delay(1000);
 }
void loop()
{
    EAST = analogRead(SLREST);
    WEST = analogRead(SLRWST);
    lux_volt= EAST * 0.00488;
    lux1= lux_volt*8.2;
```



```
    lux1= lux1/(5-lux_volt);
    lux1=500/lux1;
    lux_volt= EAST * 0.00488;
    lux2= lux_volt*8.2;
    lux2= lux2/(5-lux_volt);
    lux2=500/lux2;
    lux=(lux1+lux2)/2;
    if(EAST<250)
     {
       analogWrite(M1, 100);
     }
     else
     {
       analogWrite(M1, 0);
     }

     if(WEST<250)
     {
       analogWrite(M2, 100);
     }
     else
     {
       analogWrite(M2, 0);
     }
    if (cnt>5000)
      {
        DHT.read11(dht_apin);
        humid=DHT.humidity;
        temp=DHT.temperature;
        cnt=0;
      }
  if(Serial3.available())
  {
    if(Serial3.find("+IPD,"))
    {
     delay(300);
     connectionId = Serial3.read()-48;
     String cmd;
     char chr;
     char chr1[10];
     int cnt=0;
          int load_stat;
          load_stat= digitalRead(13);
          String webpageHEAD = "<html>\r\n <head>\r\n <script > \r\n function showUser(str) { \r\n nodid = document.getElementById(\"nodid\").innerHTML; \r\n temp = document.getElementById(\"temp\").innerHTML\r\n" ;
          webpageHEAD += "humid = document.getElementById(\"humid\").innerHTML; \r\n lux = document.getElementById(\"lux\").innerHTML;\r\n";
          webpageHEAD += "if (window.XMLHttpRequest) { \r\n xmlhttp = new XMLHttpRequest();\r\n } \r\n else { \r\n xmlhttp = new ActiveXObject(\"Microsoft.XMLHTTP\"); \r\n }";
          webpageHEAD += "var xhr = new XMLHttpRequest();\r\n";
          webpageHEAD += "xhr.onreadystatechange = function () { \r\n if (xhr.readyState == XMLHttpRequest.DONE) { \r\n // alert(xhr.responseText); \r\n } \r\n };\r\n";
```

```
          webpageHEAD += "xhr.open(\"POST\", \"http://localhost/EnergyMeter/updatekseb.php?q=\" + nodid + \",\" + temp + \",\" + humid + \",\" + lux + \", true);\r\n";
          webpageHEAD += "xhr.send(); \r\n startTime(); \r\n } \r\n";
          webpageHEAD += "function startTime() { \r\n var today = new Date(); \r\n var s = today.getSeconds(); \r\n s = checkTime(s); \r\n var t = setTimeout(startTime, 500); \r\n";
          webpageHEAD += "if (s == 59) \r\n { window.location.href = \"http://192.168.4.1\"; } \r\n } \r\n";
          webpageHEAD += " function checkTime(i) { \r\n if (i < 10) { i = \"0\" + i }; \r\n return i; } \r\n";
          webpageHEAD += "</script> \r\n</head> \r\n";
          espsend(webpageHEAD);
          String HTML_body="<body onload=\"showUser();\">\r\n";
          HTML_body+="<div id=\"nodid\">2223</div>\r\n";
          HTML_body+="<div id=\"temp\"> " + String(temp) + " </div>\r\n";
          HTML_body+="<div id=\"humid\"> " + String(humid) + " </div>\r\n";
          HTML_body+="<div id=\"lux\"> " + String(lux) + " </div>\r\n";
          HTML_body+="</div>\r\n";
          HTML_body += "</body>";
          espsend(HTML_body);
          }
    String closeCommand = "AT+CIPCLOSE=";  ///////////////close the socket connection////esp command
    closeCommand+=connectionId; // append connection id
    closeCommand+="\r\n";
    sendData(closeCommand,3000,DEBUG);
  }
delay (1);
cnt=cnt+1;
}//LOOP END
 /////////////////////////////sends data from ESP to webpage///////////////////////////
 void espsend(String d)
        {
          String cipSend = " AT+CIPSEND=";
          cipSend += connectionId;
          cipSend += ",";
          cipSend +=d.length();
          cipSend +="\r\n";
          sendData(cipSend,1000,DEBUG);
          sendData(d,1000,DEBUG);
        }
/////////////gets the data from esp and displays in serial monitor///////////////////////
String sendData(String command, const int timeout, boolean debug)
      {
        String response = "";
        Serial3.print(command);
        long int time = millis();
        while( (time+timeout) > millis())
        {
          while(Serial3.available())
            {
```



```
            char c = Serial3.read(); // read the next character.
            response+=c;
          }
      }
      if(debug)
        {
        Serial.print(response); //displays the esp response messages in arduino Serial monitor
        }
      return response;
    }
```

VI. Conclusion

With the growth of technology, this paper introduces a new method to monitor a crop field without direct inspection. The sensor node provides information about the temperature, humidity, the moisture content and ph value of the soil. In addition to this, the present situation of the crops can be visually observed through the mobile camera provided. Accurate and reliable data is obtained which is updated every one minute. Minimum error is observed because this is designed using PHP program. This experiment also concludes that, the demand for electricity can be met by the use of solar panel; because of the use of a battery, the energy requirement can be met also during the absence of sunlight and in continuous rainy days.

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