ARDUINO BASED SMART FARMING FOR THERAPEUTICAL MICRO PLANTS

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Radovan Stojanovic
University of Montenegro

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ARDUINO BASED SMART FARMING FOR THERAPEUTICAL MICRO PLANTS

Technical report (research)

Authors:
Radovan Rabrenović, Marko Tadić and Radovan Stojanović

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Abstract

Smart Farming is the process of plant monitoring, detection of disease, supply of water and fertilizers by means of Artificial Intelligence and Internet of Things. Meeting the extended expansion in worldwide interest for medicine in this century will require interdisciplinary and concurrent methodologies from plant sciences and designing to support economical rural creation. The system that we propose measure and monitor, temperature and air humidity by DHT11 sensor and soil moisture by Watermark 200ss sensor. Reading speed of the all sensor values is adjusted. Because of its huge complexity and its software structure this project has big importance. The whole project is based on ***Arduino UNO*** platform, while the user has a possibility of adjusting the reading speed of all sensors using potentiometer.

Key words: Arduino UNO, temperature measurements, soil moisture measurements, air humidity, precision farming.

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List of tables, graphs and schematic diagrams

Introduction

Our task was to measure temperature and humidity by DHT11 and soil moisture by Watermark 200ss using Arduino UNO with its components and as well as potentiometer for adjusting the working frequency. Also, the goal was to find the a solution of the mentioned problem using timer interrupt.

The work described above is implementing in the field of agriculture to grow food but not to grow therapeutical plants. Our aim is smart farming of therapeutical plants. In this field, our focus will be growth monitoring of plants which will depict the health of therapeutical plants to some extent.

Problem description

Irresistible illnesses and cancers are a few of the commonest reasons for passings all through the world. The past twenty years have seen a consolidated undertaking across different organic sciences to resolve this issue in clever ways. The approach of recombinant DNA innovations has given the instruments for creating recombinant proteins that can be utilized as restorative specialists. Various articulation frameworks have been created for the development of drug items. As of late, progresses have been made utilizing plants as bioreactors to create remedial proteins coordinated against irresistible infections and diseases. This survey features the new advancement in remedial protein articulation in plants (stable and transient), the elements influencing heterologous protein articulation, vector frameworks and ongoing advancements in existing advancements and steps towards the modern creation of plant-made immunizations, antibodies, and biopharmaceuticals.

In this project we are using 3 different sensors and each of them has a separate functionality. DHT11 is used for measuring temperature and humidity of the air, waterlevel sensor is used for measuring level of the water in the soil and watermark 200ss is used for measuring the moisture level of the soil.

Sampling frequency

Sampling frequency is adjusted by timer interrupts. Arduino has 3 timers (timer 0, timer 1 and timer 2), timer 0 and timer 2 being 10-bit (their resolution is 1024) and timer 1 is 16-bit (its resolution is 65536). Timer 1 was used for the sake of greater precision. For the interrupt to be successfully realized it is necessary to define values of all embedded registers. Registers TCCR1A and TCCR1B are set on 0 and then the certain bits were registered in them depending on their function. Considering that CTC mode was chosen (Clear Timer on Compare Match Mode), it is necessary to put 1 in place of WGM12 bit in the TCCR1B register. It is done using the command: TCCR1B |= (1 << WGM12). This command is shifting 1 for the value of WGM12 bit position. Because the compare match A interrupt is used, it is necessary to define frequency for that to happen (f_{cmpA}). Defining that frequency is done by using formula provided by the manufacturer:

$$OCR1A = \frac{f_{clk}}{N f_{cmpA}} - 1$$

In the formula above $f_{clk}$is the frequency of the Arduino UNO platform and that is 16MHz, N is the prescaler that can have values of 8, 16, 256 and 1024, and OCR1A is the register which value has the number of cycles needed for achieving wanted frequency (f_{cmpA}). Because the prescaler with the value of 256 was chosen, therefore 1 is put in the CS12 bit of the TCCR1B register. Wanted frequency is 10Hz (f_{cmpA}= 10) and prescaler value is 256, according to the formula above, calculated number of cycles is 6249. So, 6249 cycles are needed to achieve frequency of 10Hz. Compare match A is going to happen when the value of TCNT1 register gets to the value of OCR1A register, it is necessary to set TCNT1 register on 0 at the beginning. Compare match A interrupt is enabled with using OCIE1A bit in register TIMSK1. For Arduino to do interrupt it is necessary to also enable register that represents the global interrupt register. Register is enabled with the use of embedded function sei().

Figure 1 Watermarks 200 ss sensor

Watermark 200ss soil moisture sensor

The Watermark 200ss is used to measure electrical resistance of a granular matrix to calculate water tension of the soil. A voltage divider circuit is mostly used to measure resistance inside the sensor. Sensor's value is calculated by the input voltage, output voltage and series resistors value using the circuit. Example for measuring and reading the resistance of the sensor by using a digital pin for power and an analog input is Figure 1. The value is calibrated to soul water tension by the referencing look-up tables od equations, all od this once after the resistance is known. Digital devices such as Arduino/Raspberry Pi etc. can read the WATERMARK sensor, The WATERMARK sensor can be read by analog to digital devices such as Arduino/ Raspberry Pi etc., having set that some guidelines are preserved with the reading program and circuitry.

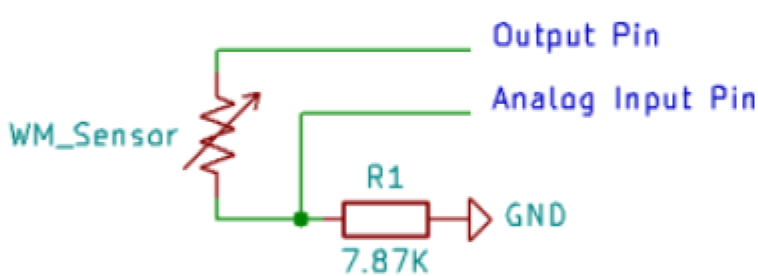

Figure 2 Connecting Watermark to Arduino UNO

Sensor Power

AC is preferred type of electrical current for processing information obtained by WATERMARK sensors, as the alternating polarity prevents building a charge that can both offset the reading and also degrade the electrodes over time. In cases where it is not practical to supply alternating current excitation, there are two other possible options:

- **1.Pseudo-AC Short Pulse** (preferred)

A "pseudo AC" created by the current direction of DC excitation for equal, but very short amounts of time. Output pins are interchanged and isolated, while the second measuring is in reverse to the charge of the previous one. This will secure that potential is not accumulated and that it is ready for the following readings now. The alternation can be done via switching the source and ground, using some additional hardware or by using a pin set low for the ground, and switching the state of the two pins back and forth. In the short pulse method, an excitation should not last more than 50ms in total and the reading should be sampled in less than 100us.

- **2.DC-Short-Pulse**

  If DC current is applied without alternating the polarities, excitation should not last more than 50ms and the reading should be taken 100us after the excitation is applied. It the reading is delayed more than 100us with a DC source, it will accumulate a charge offset on the sensor. Changing the measured resistance and reducing the life of the electrodes would be a result. After reading, the leads should be connected together or the powered side should be connected to ground for 30 seconds to remove any accumulated DC potential in the sensor.

Calibration

The Rx value is based on the amount of moisture inside of the sensor, but an additional calibration is necessary to relate the resistance to soil water tension. The following equation is the one developed by Dr. Clinton Shock in 1998 and it is the most commonly used:

$$kPa = \frac{-3.213R - 4.093}{1 - 0.009733R - 0.01205T}$$

R stands for resistance in kOhms and T is temperature in centigrade. Only the range of 10 to 100 kPa is covered by this calibration method and for ranges below 10 and above 100 kPa, linear extrapolations are usually used. It must be noted that a fully wet sensor measures 550 Ohms. Also, temperature affects the measured resistance in the sensor. A default temperature of 24 degrees centigrade can be used in the absence of temperature data, but use of temperature sensor input is advised for increased accuracy. IRROMETER devices are calibrated using a method based on this equation.

Sensor Hydration Before Installation (RECOMMENDED)

For the first use, the Watermark should be submerged in water by submerging about 50 percent of it's body for 25-35 minutes in the firs scope.

Full wrapping with too much water of the sensor could cause the problems by trapping the air inside. Of course, there is solution if the mistake is made. Watermark has to be dried adequately and restart the procedure.

If there is free space in the atmosphere there is the possibility for stucked air to breakout above. This way, the capillary force is allowed to pull water. This is the fastest way to get the sensor prepared for installation.

Drying is required for at least 3-5 hours.

Now, submerge sensor in water by submerging about 50 percent of it's body for 25-35 minutes in the second scope.

Drying is required for at least 3-5 hoursl, again.

Finally, fully submerge the sensor over the night and install soaking wet in the 3rd morning. Full sensor accuracy will be reached after two or more irrigation cycles, depending on the soil’s wetness.

Parts of the Watermark

A. Two 20 AWG wires: electrical connectors between the measurement device (e.g., datalogger) and the electrodes (C)

B. Weep slot: drain for standing water above the sensor sleeve (D)

C. Two electrodes: concentric, ring-shaped, stainless-steel bands; the measurement device reads the electrical resistance between these bands

D. ABS sensor sleeve: compartment whose water content changes the electrical resistance between the electrodes (C)

E. Gypsum wafer: source of salinity buffering for water inside the sensor sleeve (D)

F. Loose, graded sand: material that water moves through between the outside soil and the electrodes (C)

G. Mesh fabric: filter that allows water but not sand (F) to pass through

H. Steel cage: protection for the mesh fabric (G)

I. ABS plug: cap for the bottom of the sensor

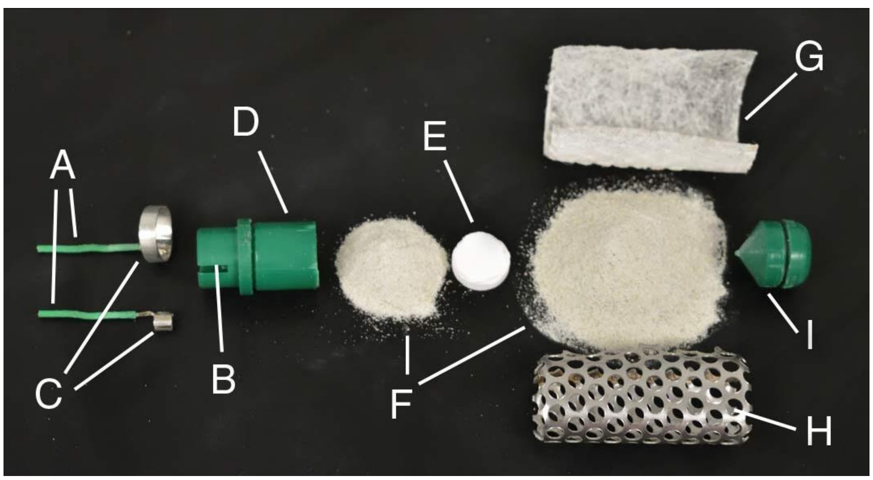

Figure 3 Parts of Watermark 200ss

Code

```
#include "DHT.h"

#define DHTPIN 7
#define DHTTYPE DHT11

#define aPinWmark A0
#define aPinWlevel A1
#define potenciometar A2
//#define potenciometar 341

DHT dht(DHTPIN, DHTTYPE);
int brojac = 0;
char duzina_trajanja;
int a = 1;
int vrijednost_potenciometra = 0;
int max_vrijednost_sekundi = 3;

int aValueWmark;
int aValueWlevel;
double WlevelCalibrator = 6.8;

void setup() {
  // put your setup code here, to run once:
  cli(); // disable all interrupts
  TCNT1 = 0;
  TCCR1A = 0;
  TCCR1B = 0;
  TCCR1B |= (1 << WGM12); // CTC mode
  TCCR1B |= (1 << CS12); // preskaler
  OCR1A = 6249;
  TIMSK1 |= (1 << OCIE1A); // enable compare match A interrupt
  sei(); // enable all interrupts
  pinMode(aPinWmark, INPUT);
  pinMode(aPinWlevel, INPUT);
  Serial.begin(9600);
```

```
  dht.begin();
}

void loop() {

  if(brojac == 1) {
    citanje_senzora();
    vrijednost_potenciometra = analogRead(potenciometar);
    //vrijednost_potenciometra = potenciometar;
    aValueWmark = analogRead(aPinWmark);
    aValueWlevel = analogRead(aPinWlevel);
  }
}

ISR(TIMER1_COMPA_vect) {
  brojac ++;
  if(brojac == a*10) {
    a = ((vrijednost_potenciometra*max_vrijednost_sekundi)/1023) + 1;
    brojac = 0;
    Serial.print("Vrijeme ocitavanja senzora je: ");
    //Serial.println("Temperatura:,Vlaznost vazduha:,Watremark 200ss:,Nivo vode:");
    Serial.println(a);
  }
}
void citanje_senzora() {
  float hum = dht.readHumidity();
  float tem = dht.readTemperature();
  if (isnan(hum) || isnan(tem)) {
    Serial.println(F("Failed to read from DHT sensor!"));
   // Serial.println("Temperatura:,Vlaznost vazduha:,Watremark 200ss:,Nivo vode:");
    return;
  }
  Serial.print("Temperatura je: ");
  Serial.println(tem);
  Serial.print("Vlaznost: ");
  Serial.println(hum);
  Serial.print("Watermark 200ss: ");
  Serial.println(aValueWmark);
  Serial.print("Waterlevel: ");
  Serial.print(aValueWlevel/WlevelCalibrator);
  Serial.println("%");
  Serial.println();



}
```

Sheme

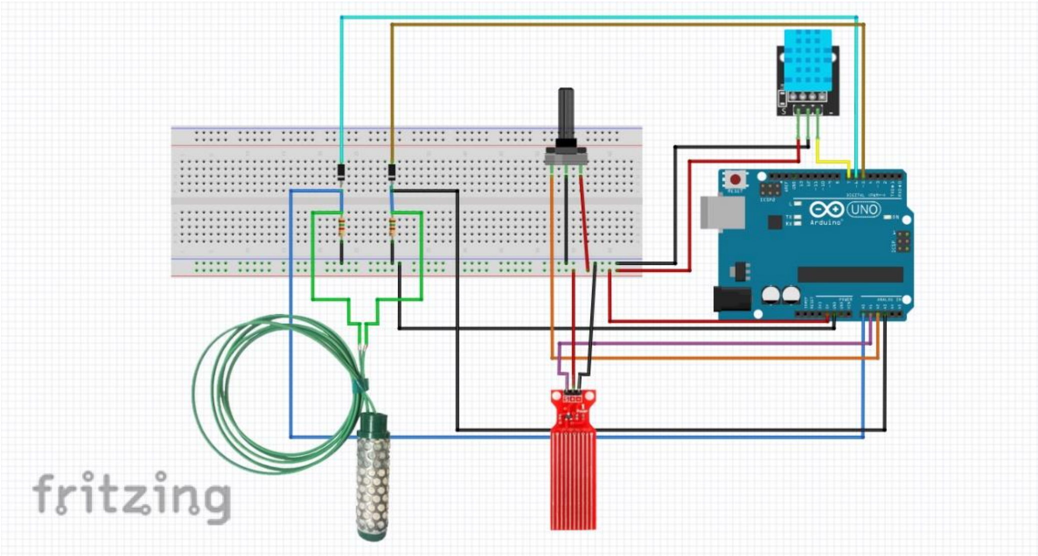

Figure 4 Scheme

Project realization

The picture shows all necessary components which will be used in this project:

- Watermark 200ss
- DHT11
- Waterlevel sensor
- Potentiometer
- ArduinoUNO
- Diode
- Wires

Figure 5 Componets

The next picture shows the operation of the sensor, which by its work reduces water consumption and in the same time increases yield in terms of quality and quantity for plants that will be used to treat various diseases.

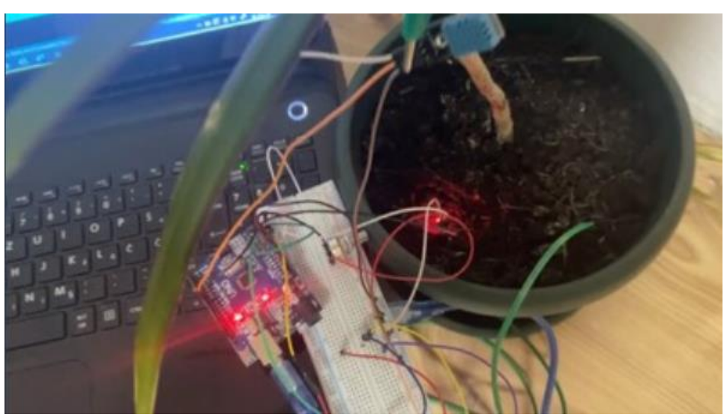

Figure 6 Project

Plant watering

The picture shows how we pour into a flowerpot with medicinal plant with water necessary for its growth and life, so that it can later contribute to medicine, during the process we consume a minimum sufficient amount of water.

Figure 7 Plant watering

The following picture shows serial monitor on which customer can observe changes in temperature, humidity and other parameters. Also, on serial monitor is shown value of the potentiometer(sampling time)

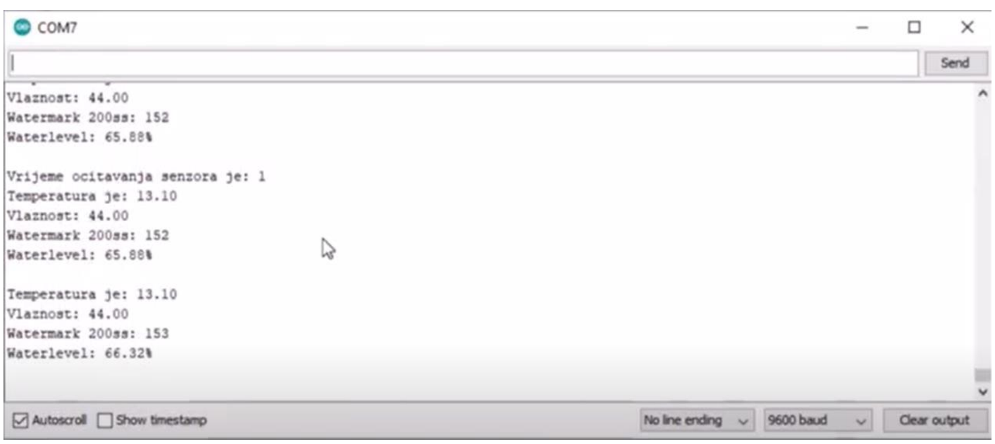

Figure 8 Serial monitor

Youtube link

https://www.youtube.com/watch?v=0SU_tEkb3yo&t=4s

Conclusion and further work

In the field of medicines, extraction of vaccines through plants is an emerging field. Therapeutical plants are therefore of great importance. As technology is gainingmaturity in the field of agriculture, so we can apply techniques of smart technology in the production of therapeutical plants as well as in the extraction of vaccines. Soil condition and temperature conditions plays important role in growth of plants and the amount of fertilizers should be appropriate for the health of plants. By using modern technology described above, we can monitor the plant growth, soil fertility, harsh conditions, temperature monitoring, water absorption, need of fertilizer, diseases and potential of required parts used in the extraction of vaccines. The useful actuators will be pump driver, servo motor and water pump. Temperature sensors, pH sensors and moisture sensors can be used to monitor health of plants. These sensors and actuators will be connected to the microprocessor. Microprocessor will deliver data to remote locations through IOT where artificial intelligence would be used to recognize the potential diseases and various needs of plants. In this way can build a small SCADA setup for therapeutical plants or using NODEMCU sensor as it is given in [5] . Opinion of experts will always be needed while monitoring.

Literature

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