LAUTECH Journal of Engineering and Technology 11 (1) 2017: 42-46

DEVELOPMENT OF A GROUND-BASED MODEL FOR REMOTE CROP CONDITION MONITORING SYSTEM

[1]Alo, O.O., [2]Fenwa D.O., [3]Alade, O.M and [4]Agbeleye, E.O.

[1,2,3,4]Department of Computer Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Corresponding Authors: ooalo@lautech.edu.ng; odfenwa@lautech.edu.ng; oalade75@lautech.edu.ng

ABSTRACT

Agricultural activity is not only one of the basic activities of the human society, but also the premise for the development of human society. Besides, it has close relation with the development and stabilization of nowadays society. It is of great significance to monitor the growth level of crops in order to obtain crop condition information at early stages in the crop growing season thereby, resulting into a good and quality product at the point of harvest, hence improve food security. This paper develops a ground-based model for remote crop condition monitoring system using the Arduino platform. Considering temperature – a major factor that affects the growth of crops and destruction of farm products by pests, animals or objects. This model was designed to sound an alarm when temperature rises beyond 40^{0}C or approaching 0^{0}C or when a destructive object is detected. The model uses electronic devices like the breadboard, Arduino board, Ultrasonic sensor, Liquid Crystal, Display, Piezo Buzzer and the LM35 temperature sensor. For the purpose of simulation, the model circuit was fabricated using the Proteus Design Suite software. The operation of the model is designed and tested using the Arduino software.

Keywords— Agriculture, Ground-Based Model, Monitoring System, Sensors, Microcontroller, Simulation

1 INTRODUCTION

Agricultural activity is not only one of the basic activities of the human society, but also the premise for the development of human society. Besides, it has close relation with the development and stabilization of nowadays society (Tilman, Balzer, Hill and Befort, 2011). It is of great significance to monitor the growth level of crops thereby, the use of remote sensing is necessary, as the monitoring of agricultural activities faces special problems not common to other economic sectors (Kastens, Martinko and Lee, 2005). First of all, agricultural production follows strong seasonal patterns related to the biological lifecycle of crops. The production depends secondly on the physical landscape (e.g., soil type), as well as climatic driving variables and agricultural management practices. All variables are highly variable in space and time. Moreover, as productivity can change within short time periods, due to unfavorable growing conditions, agricultural monitoring systems need to be timely. This is even more important, as many items are perishable. Thus, as pointed out by the Food and Agriculture Organization (FAO, 2011), the need for timeliness is a major factor underlying agricultural statistics and associated monitoring systems—information is worth little if it becomes available too late.

However, obtaining crop condition information at early stages in the crop growing season is also very important, sometimes it is even more important than acquiring the exact production after harvest time. The remote crop condition monitoring system significantly contribute to providing a timely and accurate picture of the agricultural sector, as it is very suitable for gathering information over large areas with high revisit frequency. Thus, large scale crop monitoring can provide decision-making information for the working-out of agricultural policy; it is also the necessary premise for crop production estimation (Campbell,1996).

2 RELATED WORKS

This section is strictly devoted to the review of the theoretical background of this work. This reviews other similar work proposed and achieved. The desired objective is to position this paper with respect to existing works and findings and improving on their shortcomings.

2.1 *Case One*

The papers of Zhang, Feng and Yao (2013) and Atzberger and Rembold (2013) show how remote sensing can be used to map past and present conditions of crops. This permits, for example, gaining evidence regarding the effects of (agricultural) policies on food production. A timely, comprehensive, transparent, accurate and unbiased agricultural monitoring system also prevents excessive market speculation and resulting price spikes. As the poorest people are generally the most affected by rising food prices. Hence the social component of an effective monitoring system becomes visible (Naylor, 2011).

2.2 *Case Two*

Christopher Lee (2002), postgraduate student of University of Tennessee Knoxville developed a Ground-Based Remote Sensing System with Modulated Illumination for Diagnosing Nitrogen Status in Cotton. The prototyped system was tested on DP451 BRR cotton with four different N application rates. Based on a nitrate analysis, three nitrogen status classifications were identified: low, medium, and high. Analysis of spectral data collected revealed reflected light energy in the red region produced the highest linear correlation with N status ($r = –0.7285$). The system has shown great potential in diagnosing N status in cotton under controlled field conditions. Limitation of this work require that future testing should be performed to evaluate the system for multiple varieties, growing seasons, and other variables known to contribute to plant health variability.

This paper involves the development of a ground-based model for remote crop condition monitoring system using the Arduino platform. The simulation of the model was designed using Proteus Design Suite – simulation software to monitor the growth of the crops to certify that, any change in temperature which is above or below normal temperature required and also detecting disturbances (e.g. fire, insert and animal attacks), which can cause stunted growth in crops and potential destructive objects respectively would be sensed. An intelligent message would be sent and displayed on a screen while an alarm would be sounded to notify the farmer in charge. In developing this model, a microcontroller would be automated to activate the sensors that was attached to the microcontroller, in order to collect readings, record, analyze data and be able to sense any abnormality that may occur.

3 SYSTEM DESIGN AND ANALYSIS

3.1 *The Model Design*

At first, the design of this model was designed on the electronic breadboard and devices like, Arduino board, Ultrasonic sensor, Liquid Crystal, Display, Piezo Buzzer and the LM35 temperature sensor were practically connected to test the model. The Arduino board connected to the computer through a USB cable was powered by the computer and the voltage supply was regulated by the 78L05 voltage regulator on the Arduino board. This circuit design was used in fabricating the model in the Proteus software. The power supply for the simulation was derived from the direct power supply of the computer system used, but controlled through the simulation software such that the whole system is powered by a +5V power supply as required by the Arduino package. Each sensor was added and tested one by one after uploading the compiled code contained in the hex file generated using the Arduino software.

This paper focuses on three major aspects; the importance of remote sensing systems in agriculture, the concept of remote sensing systems and the development and simulation of a model for a remote crop condition monitoring system. The whole system is controlled by the ATMEGA 328 microcontroller, alongside with some other sensors; the LM35 (Temperature sensor), and Ultrasonic sensor. The entire work is powered with a 5V dc supply by computer system in use, as shown in figure 1, since the microcontroller requires a 5-volt supply, the model design done using the electronic breadboard has the same power supply as the fabricated circuit designed in Proteus. The power supply section is shown in figure 1.

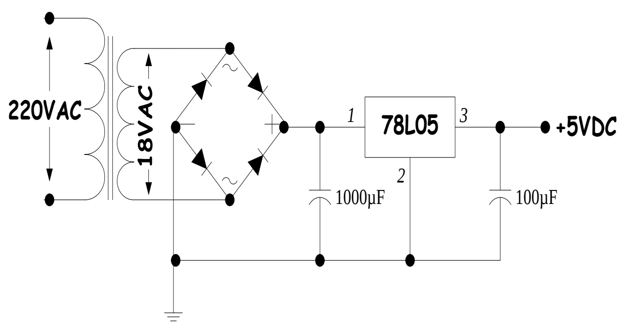

Fig. 1: Model Power Supply Breakdown

3.2 *The Microcontroller Section*

The microcontroller section is implemented by using the common and multipurpose ATMega328 microcontroller. ATmega328 (also known as Atmel) has a total number of 28 pins. It is regularly found in a DIP28 type, and it can also be found in SMD (Surface Mount Device) type which is smaller from a DIP (Dual in Package). ATmega328 and its pin labels, as shown in figure2, is the electronic device (microcontroller or integrated circuits) that stores all the information required for the model to perform its functions and enable the simulation of the developed model. Table 1 below, explains the pin description of the ATMega328. Each pin has its own function however, not all pins will be used in the design of the model. The digital pins D0 – D7 are responsible for connecting the microcontroller to digital devices.

The LCD screen display component used in the design of this model is a digital device and it is connected to the digital pins of the microcontroller for effective results. The analog pins PC_0 – PC_5 on the microcontroller as shown in Table 1 are responsible for making analog devices like the temperature sensor (the LM35 temperature sensor) work. The electronic configuration of ATMega328 housed by the Arduino board component in Proteus as shown in figure 3.

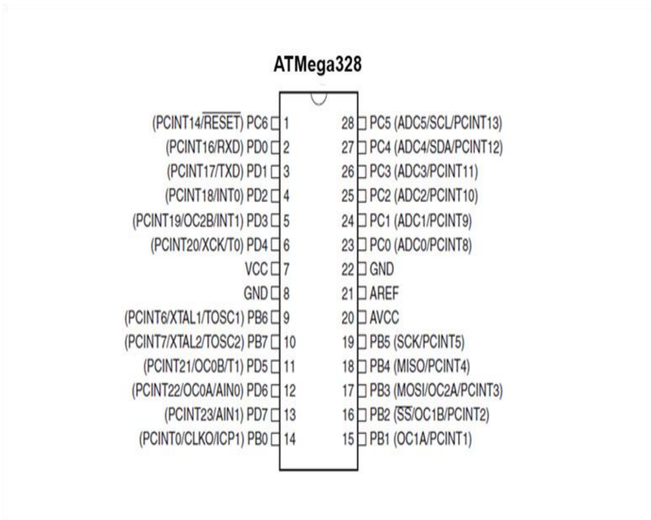

Fig 2: Pin-Out of the Micrcontroller ATMega 328P

Table1: Pin Description Of The Microcontroller Atmega328p

Pin Number	Description	Pin Functions
1	PC6	Reset
2	PD0	Digital Pin RX
3	PD1	Digital Pin TX
4	PD2	Digital Pin
5	PD3	Digital Pin(PWM)
6	PD4	Digital Pin
7	VCC	Positive voltage power
8	GND	Ground
9	XTAL1	Crystal Oscillator
10	XTAL2	Crystal Oscillator

11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positivevoltage reference for ADC
21	AREF	Reference Voltage
22	GND	Analog Input
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

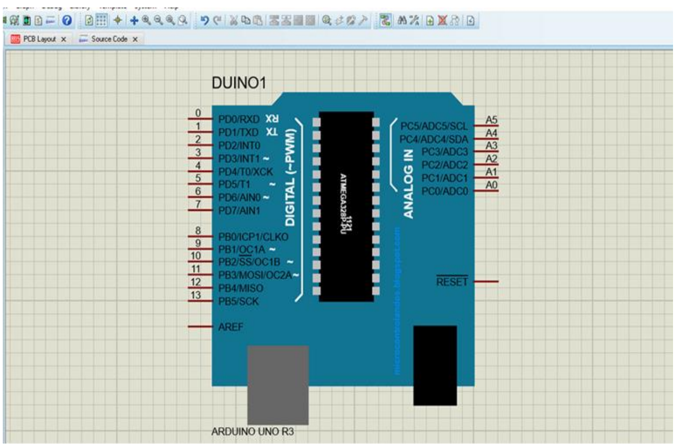

Fig 3: The Microcontroller In The Simulation Software Proteus

3.3 The Circuit Designs

The model, following the design done on the electronic breadboard was fabricated using Proteus software and it is composed of the Arduino board component, the temperature sensor component, the ultrasonic sensor component, the piezo buzzer component and the LCD (liquid crystal display) component. These components are accessed via their libraries located in the library section of the Proteus software. The Arduino board is the major electronic device that houses the microcontroller which controls the activities of the whole model in order to get effective simulation results. Figure 4, shows the model design and the connection of each component with the microcontroller on the Arduino board in Proteus.

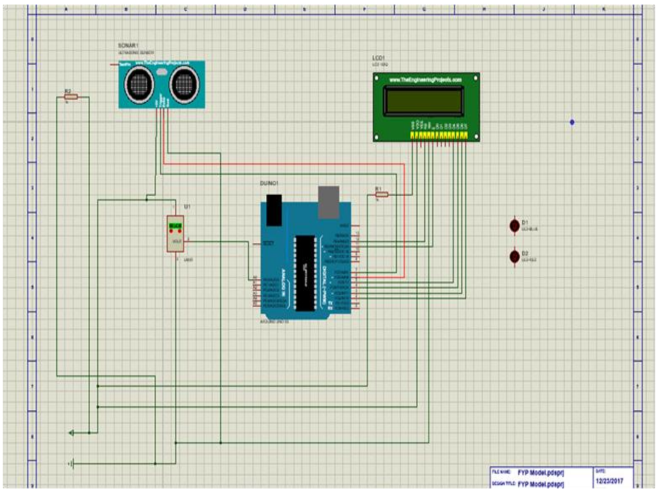

Fig 4: Circuit Design For The Remote Sensing Model In Proteus

4 RESULTS AND DISCUSSION

4.1 Overview of Result and Discussion

This paper presents the discussion on the result obtained in the course of simulating the model designed and the simulation stages involved. The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. Proteus is a Windows application for schematic capture, simulation, and PCB layout design and the components used in Proteus are accessed via libraries downloaded and installed into Proteus. These components are enabled electronically for simulation (in the case of using a microcontroller) by Proteus after a suitable error-free program has been uploaded to the microcontroller component used. In this work, Proteus play an important role in simulating the model designed. Model components are arranged and connected in Proteus to enable the simulation give expected results.

4.2 Temperature Sensor

The hex file, generated by the Arduino software after compiling the written program was uploaded on to the microcontroller housed by the Arduino board component in Proteus. The Arduino software ensured that there is no error in the program, as this might cause the microcontroller to malfunction. The model is designed in such a way that it measures the temperature of the crop's environment and as well detect the objects (like insects and animals) on the farmland. Figure 5 shows the temperature of the environment as read by the temperature sensor which was 27.34OC and the LCD displays the value. At this point, the temperature of the environment is normal because it is not too high or too low according to the standard temperature range for the effective growth of crops on a farm i.e. 0OC – 40OC.

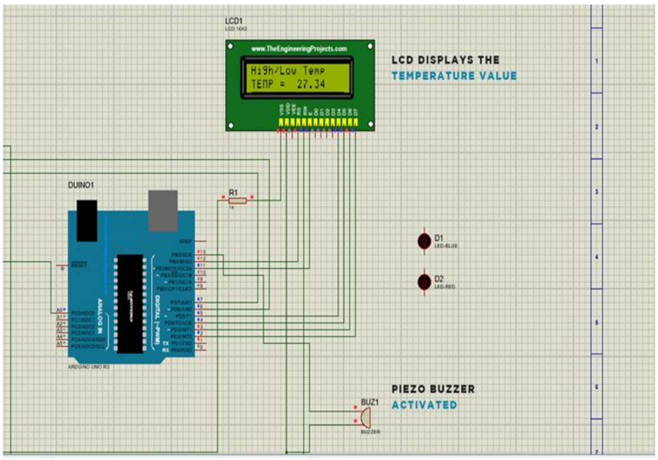

Fig 5: LCD Displaying Temperature Message While Buzzer Is Activated

The accuracy specifications of the temperature sensor are given with respect to a simple linear transfer function:

$V_{OUT} = 10$ mv/°C × T. (1)

Where:

- V_{OUT} = is the LM35 voltage output
- T is the temperature measured in °C

The temperature at which most physiological processes go on normally in plants range from approximately 0°C. to 40°C. Very high and very low temperatures causes injury effects and this allows the drawing of certain conclusions about the physio-chemical processes involved in the growth of crops. In this model, the temperature sensor helps to monitor the temperature of the environment of the crop by measuring the temperature and giving outputs. However, if the temperature is too high or too low, the microcontroller activates the alarm (buzzer) to notify the farmer.

4.3 The Ultrasonic Sensor

The ultrasonic sensor measures object distance as to how close or how far they are from the plants on the farm. In this model, the ultrasonic sensor is used to detect objects that may prove quite destructive to the crop on the farm. An alarm will be triggered to notify the farmer as soon as an object is detected. According to the standard Arduino use of the ultrasonic sensor, the formulas in the equations below show how the distance to an object is calculated in both centimeter and inches.

Distance(cm) = time(µs) / 29 / 2 (2)

Distance(inch) = time(µs) / 72 / 2 (3)

In figure 6, an object has been detected and the values of the distance of the object to the crop is displayed on the LCD screen, the buzzer is activated to sound an alarm in order to call the attention of the farmer to what is happening on the farm at that point in time, so as to prevent the crop from being damaged.

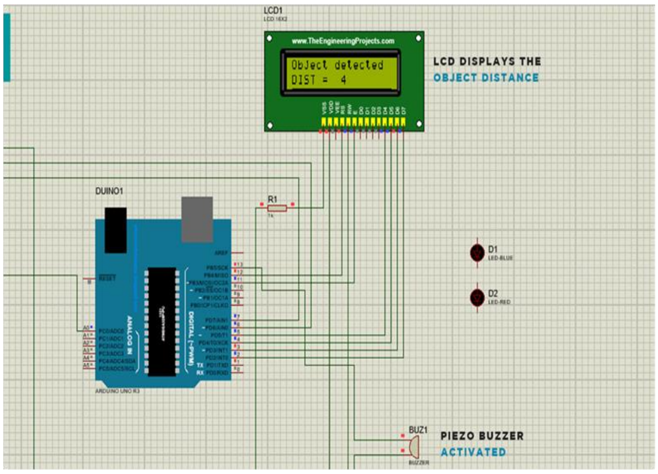

Fig 6: Displaying Object Distance Message With Buzzer Activated.

5. CONCLUSION

In order to help farmers, produce high quality crops, monitor the crops during growth and supply good food items to the community, is mainly focus of this paper. This paper designed a model that simulates a ground-based remote sensing system for monitoring plants/crops, considering the temperature of the crop and detecting destructive objects that can damage the crop or cause it to have a stunted growth. Further work should be done on the area of remote sensing for agricultural products for farmers by practically demonstrating the design on a farmland. Also, improvement on data processing is needed; this structure should be put in place in order to gather relevant and useful data that can help in the design and implementation of a working model for monitoring crops. An online implementation of this model can be considered alongside with software to enable interfacing the PC and a mobile phone, in order to be able to send messages to a farmer's mobile device – in the case of farmers who live far away from their farmlands.

References

1. Atzberger C. and Rembold F.(2013): "Mapping the spatial distribution of winter crops at sub-pixel level using AVHRR NDVI time series and neural nets". Remote Sens. 2013, in review.

2. Campbell J.B.(1996):Introduction to Remote Sensing,2nd Edition, Guildford Press, NY .

3. Christopher Lee,Whitten(2002)"Development of a ground- based remote sensing system with modulated illumination for diagnosing Nitrogen status in Cotton",M.Sc Thesis, Department of Biosystem Engineering, University of Tennessee Knoxville.

4. Food and Agriculture Organization of the United Nations (FAO)(2011):Global Strategy to Improve Agricultural and Rural Statistics; Report No. 56719-GB; FAO: Rome,Italy, 2011.cert. Motor. Retrieved June 24, 2016, from http://www.ncert.nic.in/html/learning_basket/electri

city/electricity/machine/motor.htm.

5. Kastens J.H, Martinko E.A and Lee R.Y.(2005): "Image for crop yield forecasting using AVHRR NDVI time series imagery", Remote Sens.Environ Vol 99, pp.341–356

6. Naylor R.(2011): "Expanding the boundaries of agricultural development", Food Secur. Vol 3, pp. 233–251.

7. Tilman D., Balzer C., Hill J and Befort B.L.(2011): "Global food demand and the sustainable intensification of agriculture", Proc. Natl. Acad. Sci. USA,Vol.108, pp.20260–20264.

8. Zhang J., Feng L., and Yao F.(2013):"Crop area extraction by the integration of MODIS-EVI time series data and China's high spatial resolution Environment Satellite (HJ-1) data", Remote Sens. in review.