AN AUTOMATIC IRRIGATION CONTROL SYSTEM

Eng Zakaria Mukiibi[1]*, Jeremiah Kwibe Merci[2], Natuhwera Phionah[3]

1-St.Lawrence University, Uganda [corresponding author Email: mukiizex@gmail.com]
2-St.Lawrence University, Uganda [Email: kwibemeric12@gmail.com]
3- St. Lawrence University, Uganda [Email: phionahh10@gmail.com]

ABSTRACT

This paper presents the design and construction of an automatic irrigation control system using a micro controller, the GSM technology, (MONI) web application to remotely operate, control and access irrigation equipment, such as sprinkler, solenoid valves, and pumps through remote web application client like a web browser. Automatic irrigation control system is the automatic control and monitoring to the status of garden soils moisture, humidity, temperature and fertility .We demonstrate the auto switching ON and OFF the electrical irrigation system equipment controlled via a micro controller that manages a relay based on moisture levels. Our findings indicate that monitoring this system may be done even on a web internet through a computer where by the system administrator alters settings and parameters for normal operation of the irrigation system.

Key words: Microcontroller, GSM, Ethernet Shield, irrigation

INTRODUCTION

As technology becomes increasingly connected through the rise of IT and cloud computing, we have not only benefited our lives but our planet as well. Smart farming has taken the world by storm as farmers have learned to embrace the world of IT. Farmers have been able to precisely monitor conditions of their produce with regard to the natural environment (Pubnub, 2018). This has been used to introduce the concept of networking equipment and devices on farms.

Due to the advancement of wireless technology, there are several different connections introduced such as GSM, WIFI, and Bluetooth [9]. Each of

these connections has their own unique specifications and applications. WIFI is commonly chosen with because of its suitable capability.
The capabilities of WIFI are more than enough to be implemented in the design. Also, most of the current laptop or Smartphone come with built-in WIFI adapter; this indirectly reduces the cost of this system.

Since one cannot accurately and physically detect the soil properties relating to temperature, moisture and humidity levels all the time, it becomes simpler to lean on cutting edge technology to keep a steady progress to the growing plants from the merciless tragedy from a cause of the natural changing environmental conditions resulting into the inability to meet food demands. With this there has been an implementation of automatic irrigation to avoid food shortage.
History of an Irrigation System

According to (ICID), Irrigation in Ancient Times considered water as the most important input required for plant growth for agriculture production. Irrigation was defined as a replenishment of soil water storage in plant root zone through methods other than natural precipitation. Refer to figure 6 of the appendices, Irrigation was seen to have found its roots in the history of mankind since earliest beginning, it helps reduce the uncertainties, particularly the climatic uncertainties in agriculture practices. In (Limited Irrigation Australia), Irrigation is an artificial application of water to the soil, usually to assist with the growth of crops. In crop production, it is mainly used in dry areas and in periods of rainfall shortfalls, but also to protect plants against frost.
Automated Irrigation System Using a Wireless Sensor Network and GPRS Module

The system has a distributed wireless network of soil-moisture and temperature sensors placed in the root zone of the plants. In addition, a gateway unit handles sensor information, triggers actuators, and transmits data to a web application. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller-based gateway to control water quantity. (Joaquín, 2014) The system was powered by photovoltaic panels and had a duplex communication link based on a cellular-Internet interface that allowed for data inspection and irrigation scheduling to be programmed through a web page.

Automatic Irrigation Control System: Smart Irrigation in IoT
According to (DZone), a smart microcontroller which serves as the 'information gateway' lies at the heart of the automated irrigation infrastructure. Soil moisture sensors and temperature sensors, which are placed on the fields, send real-time data to the microcontroller. Generally, a moisture/temperature range is specified, and whenever the actual values are out of this range, the microcontroller automatically switches on the water pump, which is mounted on it with output pins. The microcontroller also has servo motors to make sure that the pipes are actually watering the fields uniformly so that no area gets clogged or is left too dry. The entire system can be managed by the end-user through a dedicated mobile application. (Prathyusha, 2012) Stated that the Microcontroller based drip irrigation system proves to be a real time feedback control system which monitors and controls all the activities of drip irrigation system efficiently.

Types of Irrigation

Surface Irrigation

In surface irrigation systems water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil. Surface irrigation can be subdivided into furrow, border strip or basin irrigation.

Localized Irrigation

Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods

Drip Irrigation

This also known as trickle irrigation, functions as its name suggests. Water is delivered at or near the root zone of plants, drop by drop. This method can be the most water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized.

MATERIALS AND METHODS

GSM based Automation System

The system provides a means to remotely control equipment using the GSM module. The real time monitoring has been an important feature that can be used in the GSM Based Automation system. As a change in the status of the equipment occurs, the user can be informed in real time. The user commands are transferred to a server which is done by a PC. The server processes the user commands and sends them to the relevant units. This can help control the appliances.

The GSM is used as a communication medium to help establish connection in places where there may not be proper internet connectivity. The server has engines running – the web server, database and the main control program. The server uses AT (Attention) commands to communicate with the GSM modem. The mobile interface is developed using J2ME.

The system makes use of a microcontroller for the automatic irrigation control system. It makes use of GSM for control of the appliances. AT commands can be sent through the GSM network and this controls the irrigation components. Individuals will be able to control irrigation pumps as a result of primary communication through GSM. A web browser is used to get the commands and converts them into text. This is sent via SMS to through the GSM network. This module is connected to a microchip controller. This controller interprets the commands and performs the appropriate actions. The control of electrical circuits is done with a separated system, to isolate the load from the control circuitry. The system also sends back feedback to alert the user about the result of the command. This system's command feature makes it universally accessible. This command is converted to text and sent to the controller through a RS-232 bus. These commands are interpreted by the microcontroller and the corresponding action is performed

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Block Diagram of The System

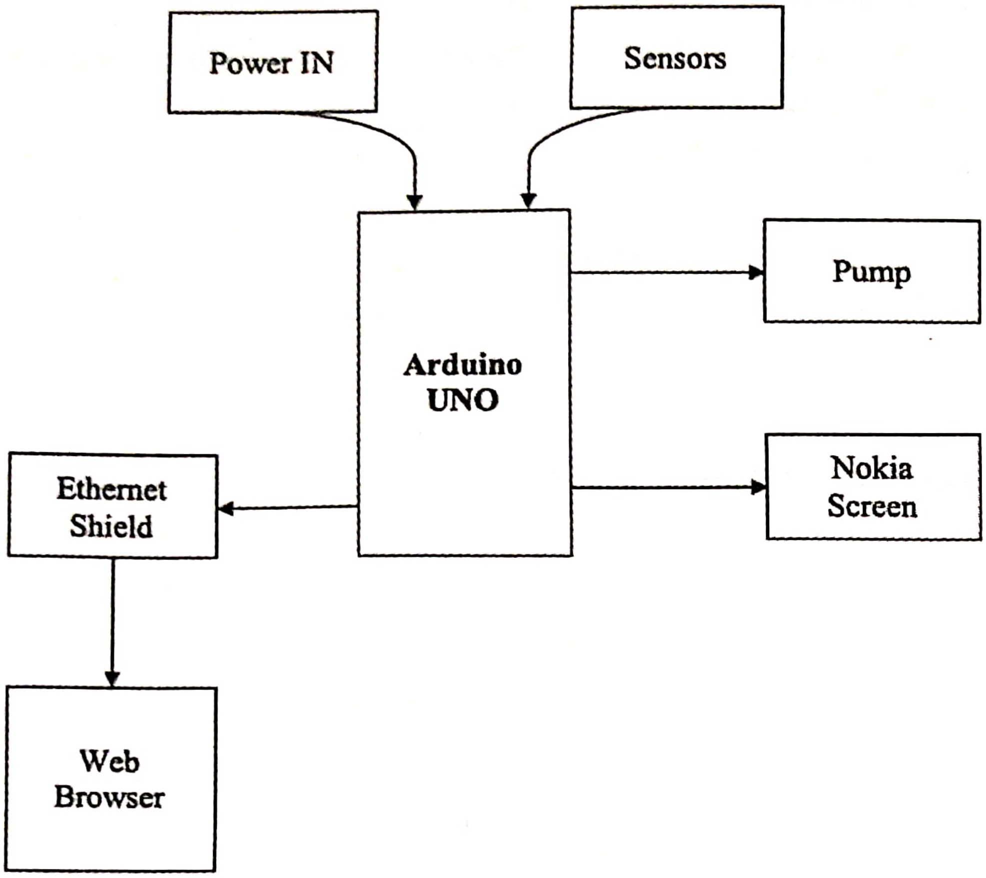


Figure 1: The Block Diagram of the System

System Design and Implementation

System Design

The designed an automatic irrigation control system involves features of Real time monitoring of soil parameters with sensors, Micro controller timely regulate the required soil conditions by turning OFF or ON the pump as per desired soil parameters. We discuss both the high and low level design. Arduino software was used to provide a lot of reusability and makes extensibility possible.

System Architecture

The software capabilities and requirements specified in the automatic irrigation control system Software Requirements Specification are transformed into programs that will execute on embedded devices.

The Sensing Component Subsystem

The sensing component subsystem shall be responsible for detecting, capturing and transmitting soil parameter data readings. The sensing component subsystem is made of the sensing modules that is to say temperature, humidity and soil moisture sensor.

The Observation Subsystem

This subsystem is responsible for receiving digital signals from the micro-controller through a USB. After receiving the signals on the computer, the status readings of the soil parameters captured are uploaded onto an LCD screen. This also in position to view and track the status levels from the comfort of their computer web browser.

The subsystem consists of:

- **LCD screen**

The microcontroller (Arduino Uno) sends processed digital signals to the LCD screen. The signals can include the data readings for the soil changing parameters to process an automatic ON and OFF of the pump / valve as per readings.

- **Web application**

This shall support the system user to set default soil parameters or even turn either ON or OFF the valves and also monitor their status via the system interface.

The relationship between subsystems

All the different subsystems are controlled by the micro-controller (Audruino Uno) since it contains all the instructions. Therefore, the programmed micro-controller acts as the center of the system because the soil data readings from the sensors at the sensing component subsystem are sent to the micro-controller. The micro-controller then transmits the readings to the observation subsystem. The LCD screen receives the readings inform of digital signals after they have been converted by the micro-controller and also the by the use of the computer web browser interface the user is be able to control the various connections of the system

Architecture Design Of The Automatic Irrigation Control System

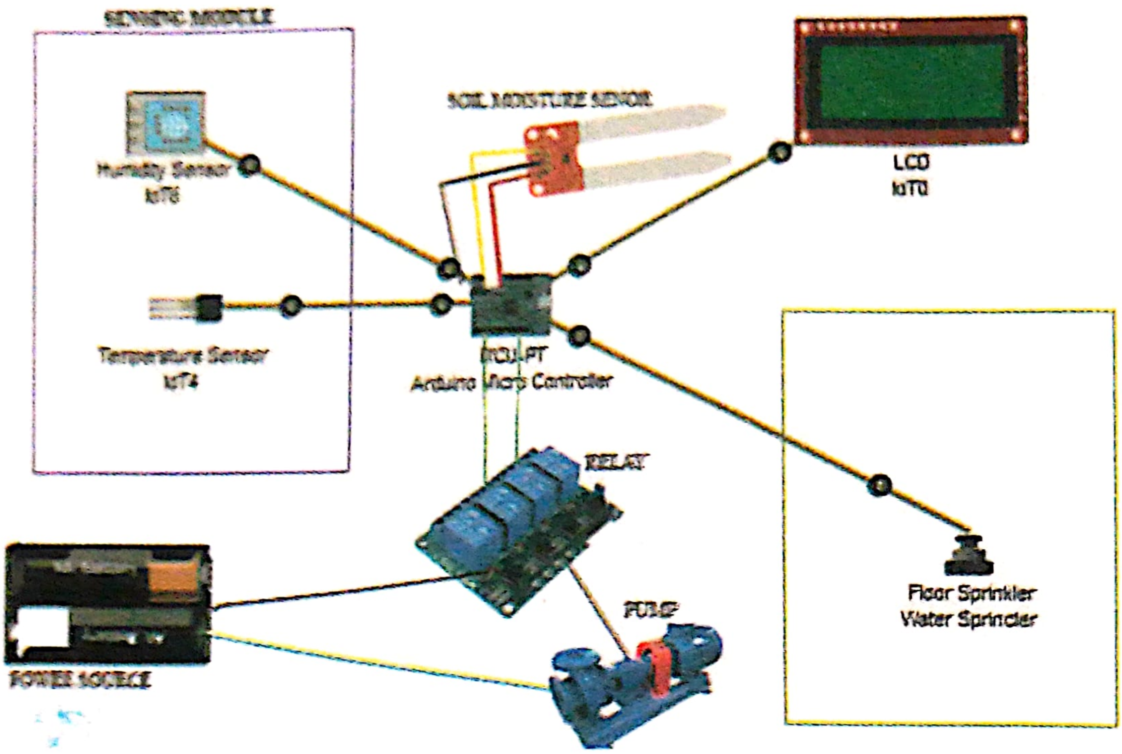


Figure 2: System high level architecture

Explanation:

In Figure 2 above, the architectural design is made up of two subsystems that is; the sensing component subsystem and the observation subsystem. The sensing component subsystem is made up of the sensors that capture the status of soil content levels that is to say temperature, soil moisture and humidity with in a specific reasonable time interval.

Data captured by the sensors is in the form of analog signals which are then transmitted to the micro-controller for conversion to digital signals that is sent to an LCD screen and also accessed or displayed on a computer web browser

Design Constraints

The automatic irrigation control system is associated with issues with, poor manageability, high cost of ownership, and difficulty of being integrated with security systems. Integrating devices from disparate vendors often results in limited functionality and unreliable service. Further, many systems on the market have complex interfaces that limit the functionality of the Automatic Irrigation Control System. The involves quietly high costs of repair and maintenance Assumptions are taken in such a way that the components of the Automatic Irrigation Control System will always be connected, that there is only one Administrator, that proper hardware components are available, that the user is capable of using a computer browser with a higher bandwidth internet connection. This system is that it requires external power supply. Also, it cannot control multiple appliances concurrently.

Design Methodology

This project was developed using an iterative approach. However performing testing during these iterations was limited due to the time constraints associated with a final project (Bach, 2017). Instead we did exploratory testing without any documentation and fixed any problems I discovered on the check. The main documented testing was done at the later stages of the development life cycle similar to the water fall method of development.

High Level Design

This view shows the logical functional elements of the system. Each component represents a similar grouping of functionality. It also views the distributed systems. The components are physical processors that have parts of the system running on them.

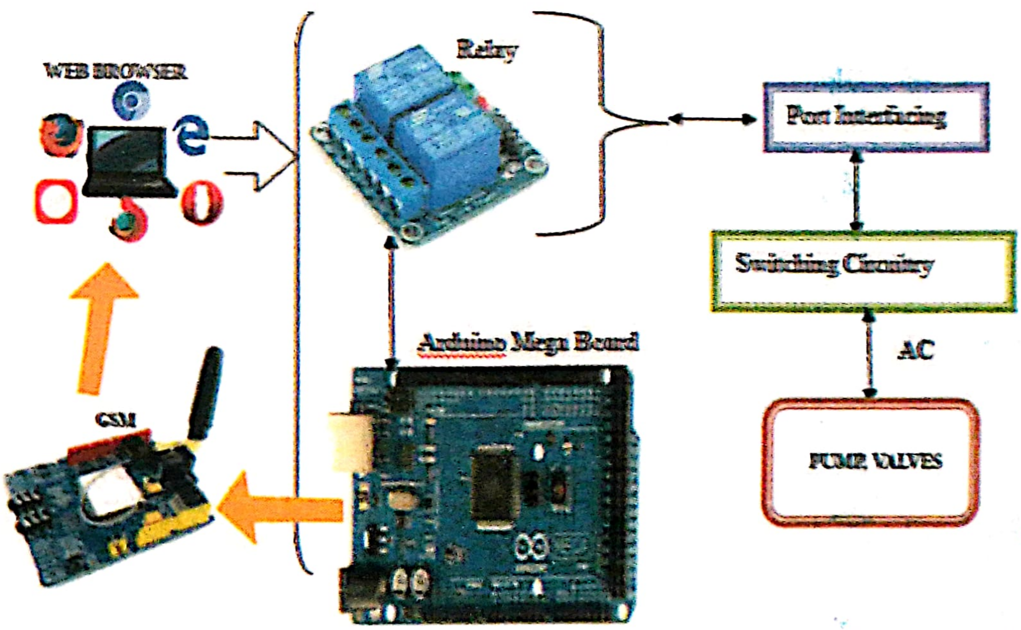


Figure 3: Block diagram

In the figure 3 above, a signal is sent from a GSM Module to a web browser, this is therefore processed under the micro-controller (Arduino Mega board) that is interfaced with a relay circuit used to connect the PC with the irrigation equipment ie. pump and valves to trigger irrigation with respect to the current readings of the soil properties. The circuit comprises of a relay (5v, 5A), a freewheeling diode, a transistor to drive the relay energizing input and connectors to interface parallel port. The valves are then either switched ON/OFF in alteration of the temperature, moisture or soil humidity level

Low Level Design

Decomposition Description

Before starting coding, it was important to break up the project into sub systems in order to iteratively build the system. This section provides a decomposition of the subsystems in the architectural design and therefore giving an idea on how the software is modularized by performing the various tasks (Togaf-Modeling).

The decomposition description in the figure 4 below provides an object oriented description on how the different sub systems perform the basic functionality

SEQUENCE DIAGRAM FOR THE AUTOMATIC IRRIGATION CONTROL SYSTEM

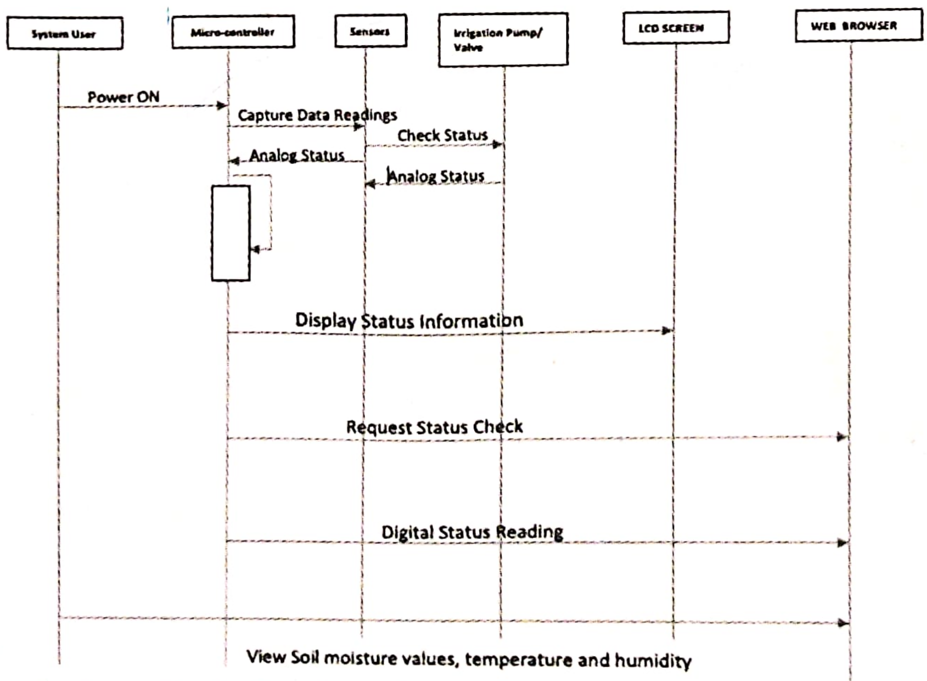


Figure 4: Automatic Irrigation Control System

Explanation:

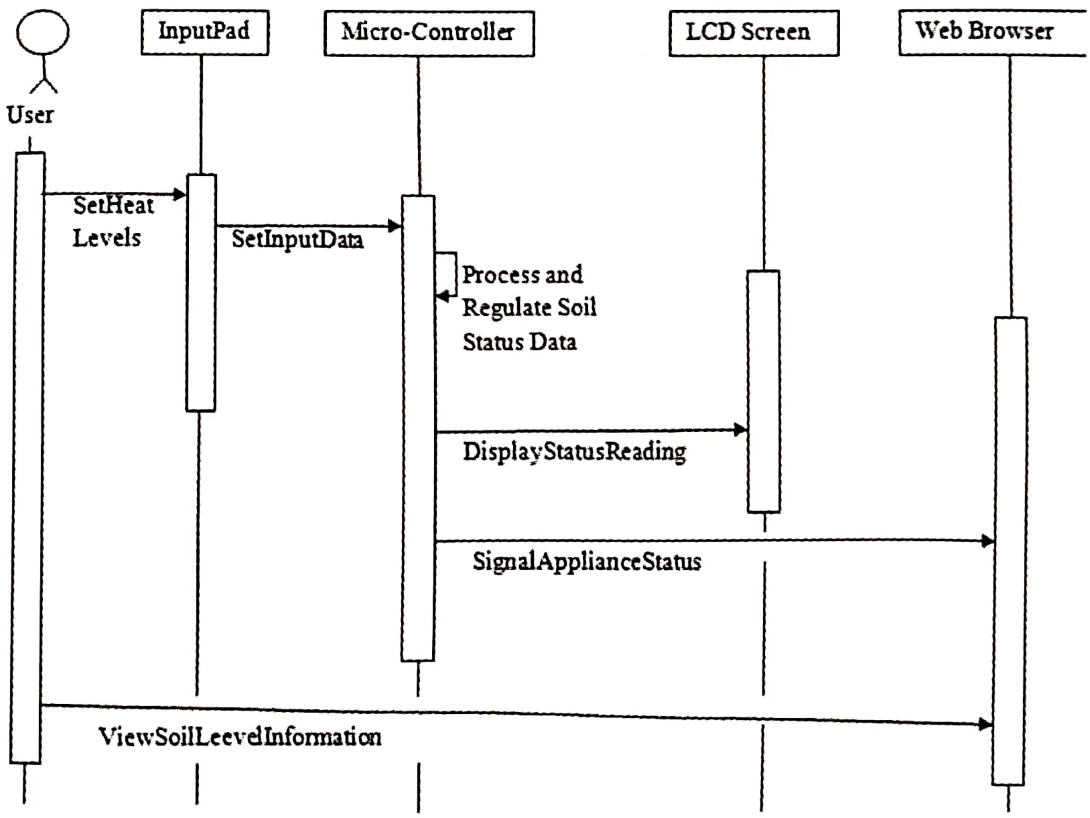
Figure 4 above describes the process from which data is captured as per change in soil property levels of temperature, moisture and humidity level readings until when they are displayed on an LCD screen. When the system is switched on (powered on) the micro-controller picks up the current status conditions of the soil levels that will be captured by the corresponding sensors in form of analog signals.

When the transmitted data reaches the micro-controller, analog signals shall be converted to digital signals that can easily out putted on the LCD screen

The micro-controller checks if the current default set soil parameters are being exceeded that is to say if the pump is either ON or OFF, the user can then get a notification message for the notification status readings on the web interface screen

The Observation Subsystem

Sequence diagram for the user on the observation subsystem



'igure 5: Sequence diagram for the user on the observation subsystem

Explanation

The Automatic Irrigation Control System User inputs standard constant readings through the input pad for the required soil levels of temperature, humidity and moisture. The readings will be based upon by the micro controller to make changes to the status conditions of the soil

The readings are therefore stored and processed by the micro controller and display the corresponding readings to an LCD screen where they will viewed by the users on their web browser

Database Design

The main repository for the Automatic Irrigation Control System data is a relational database and is where all data is stored and maintained. Instances exist to support the development, test and production so as to enhance creation and update of required heat or temperature data.

The database is normalized and converted to a MYSQL database (Visual Database Design) which is hosted on a windows machine to allow faster query performance.

RESULTS

System Implementation

Various tools have been used to develop the Automatic Irrigation Control System, these tools range from Hardware to software as detailed below.

Arduino IDE (Mega development Kit)

This tool was used to writing, compiling and deploying the hardware code of the Automatic Irrigation Control System to the micro-controller on the mega development board.

This was also the most core platforms of development for the Automatic Irrigation Control System This development board enables us to connect the micro-controller to an LCD screen and or the web application using a GSM module USB cable. This is possible because the board has inbuilt libraries that enables serial communication.

Fritzing IDE

This tool was very handy in designing and interfacing the Arduino micro controller with the Automatic Irrigation Control System circuit.

One of the most powerful features of this tool is its virtual breadboard and this feature did not only make it to a visual interaction for the system without using the real devices, it also made designing the Automatic Irrigation Control System very easy in general before the hardware components could be deployed on the large scale devices.

The System Connection Process

- The pump is connected to the relay module which is in turn connected to the power supply and the Arduino board (micro-controller) so as to control adjustments for the ON / OFF process. This micro-controller is used to writing, compiling and deploying the hardware code of the Automatic Irrigation Control System to the on the mega development board

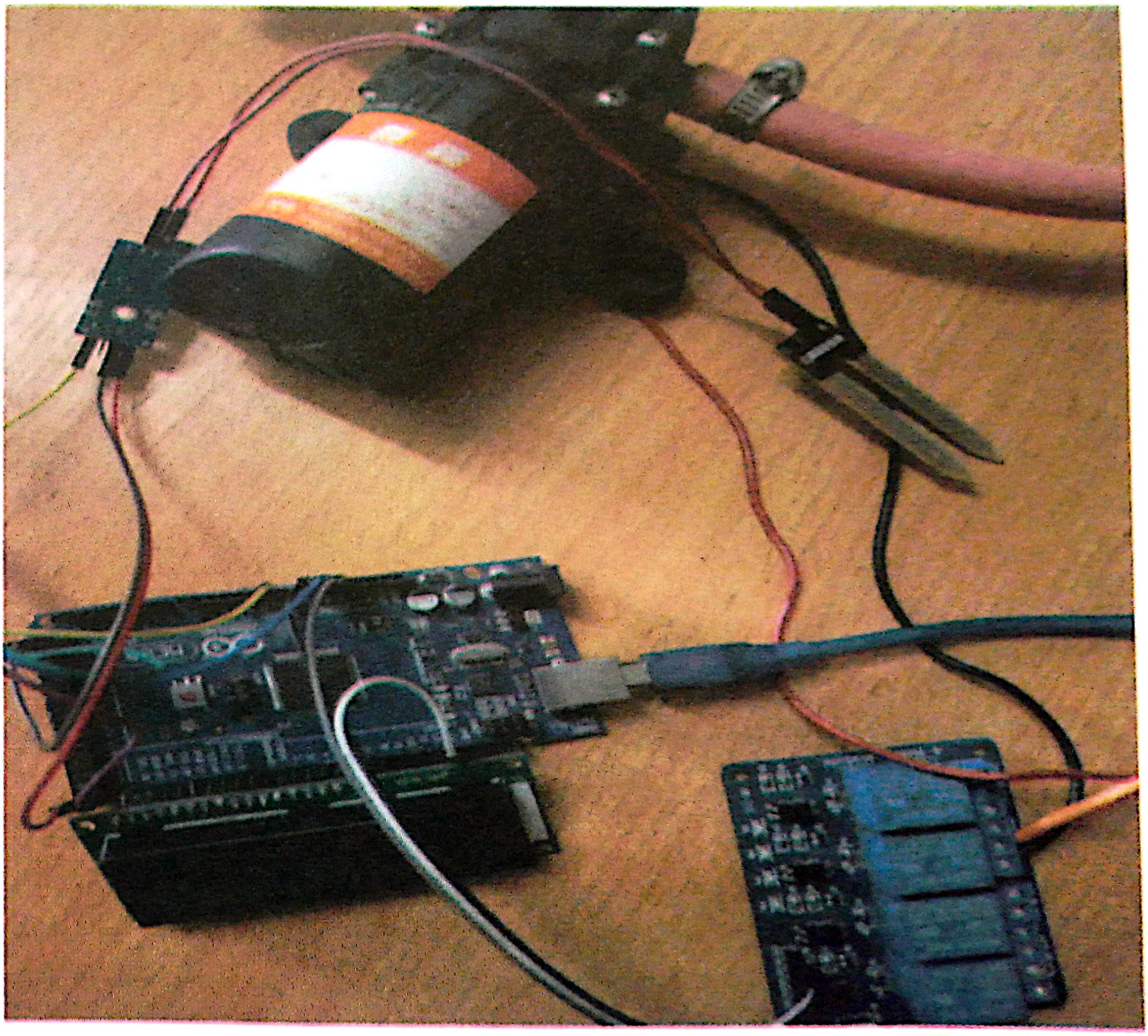


Figure 6: Pump Connection to the Arduino board

- The sensing devices ie the PH, Temperature and moisture sensor are also connected to the analog pins of the micro controller which receives the analogue readings of the attached sensors as recorded from soil ground.
- The LCD screen is connected to the digital pins of the microcontroller so as to display

Readings sent from micro controller for use viewing as per sensed conditions

- The GSM module is also connected on to the some of the remaining micro-controller pins such that the web application user is able to receive communication on the application browser.
- Connect the valves on the pump 3.5L/min with a 2A so as to adjust on the flow of water

and spiking of the triggered water to the farm gardens

For the connection process refer to the diagram as below

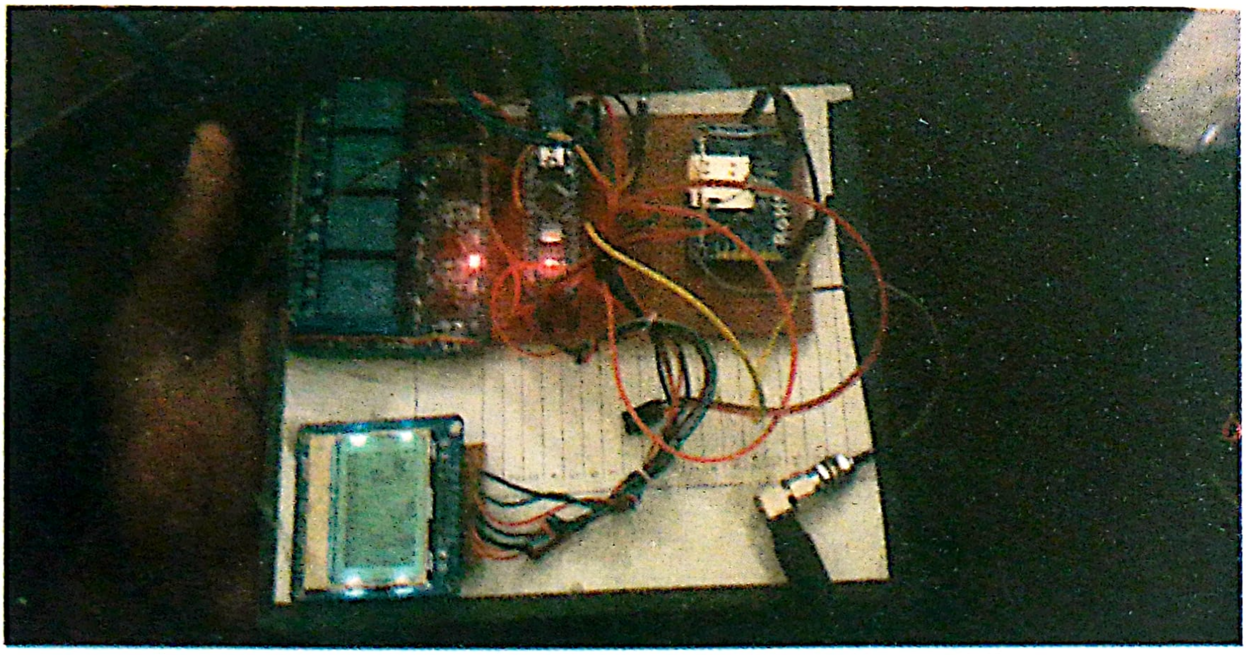


Figure 7: System Connections with a GSM Module

The system also involves the use of a mobile phone application to view the available farm products at different prices to enable farmers sell off their produces at favorable prices and dispose them off their stores to avoid costs as a result of overstocking and as a result that these might go bad.

- The GSM module is also connected to the micro-controller to ease communication

medium and establish connection in places where there may not be

proper internet
connectivity. The server has engines running – the web server, database and the main
control program. The server uses AT (Attention) commands to communicate with the
GSM modem. The mobile interface is developed using J2ME.

Project settings

The Default Acceptable conditions with respect to PH, temp and soil moisture are sent through the application browser interface of the system and stored on to the microcontroller chips memory which will compare them with current readings of the sensor to either switch on/off the pump

Quantitative and Qualitative evaluation

The system it consisted of estimated data that is evaluated with the help of suitable set of methodologies and assumptions. An in-depth and comprehensive analysis comprised of precise information towards the data on the status of the soil stated parameters with respect to the readings of the sensors on both qualitative and quantitative inputs

Strength and Ease of use

The web module usage enhances the ease to use the system because of its mobility and requires little skills of usage when an individual is experienced to using a computer web browser.

By the end of this paper we have drawn some studies present to which it has been an opportunity to derive experience for longer and more mature than would be found in a mid-term evaluation more so in a practical usage of the some major embedded device even though some were limited to the highly costs hence locally available

Functionality

There is a clear benefit to promoting cost savings and related energy efficiency that comes out of the Automatic Irrigation Control System, with 70% reporting excitement around this factor.

Similarly, the potential convenience of programming soil parameter settings and the ability to help the environment are also factors that drive excitement among nearly half of consumers.

This is expressed in terms of a greater productivity and ability to manage work-life balance, anticipate one's needs at any time with the ability to have more interactive features and an auto adjustment of soil parameter levels ("the system doing it on behalf of the individuals and even not to depend on environmental readings") through devices using data, analytics and sensors to work on their own.

Errors realized

The system varies to the environmental temperature in such a way that temperature is not stably noted for that of the farm soils and this is a cause to by the nearby environment temperature readings hence bringing to a note that a total accuracy is not recorded by the respective sensor

Failed steps and Finals made

The system was believed to use a GSM mode which was not perfectly working with an unstable internet connection in support with the Arduino Nano micro-controller, therefore this required a change to an alternative dependable device of an Ethernet shield HanRun HR911105A 19/06 with an Arduino Uno.

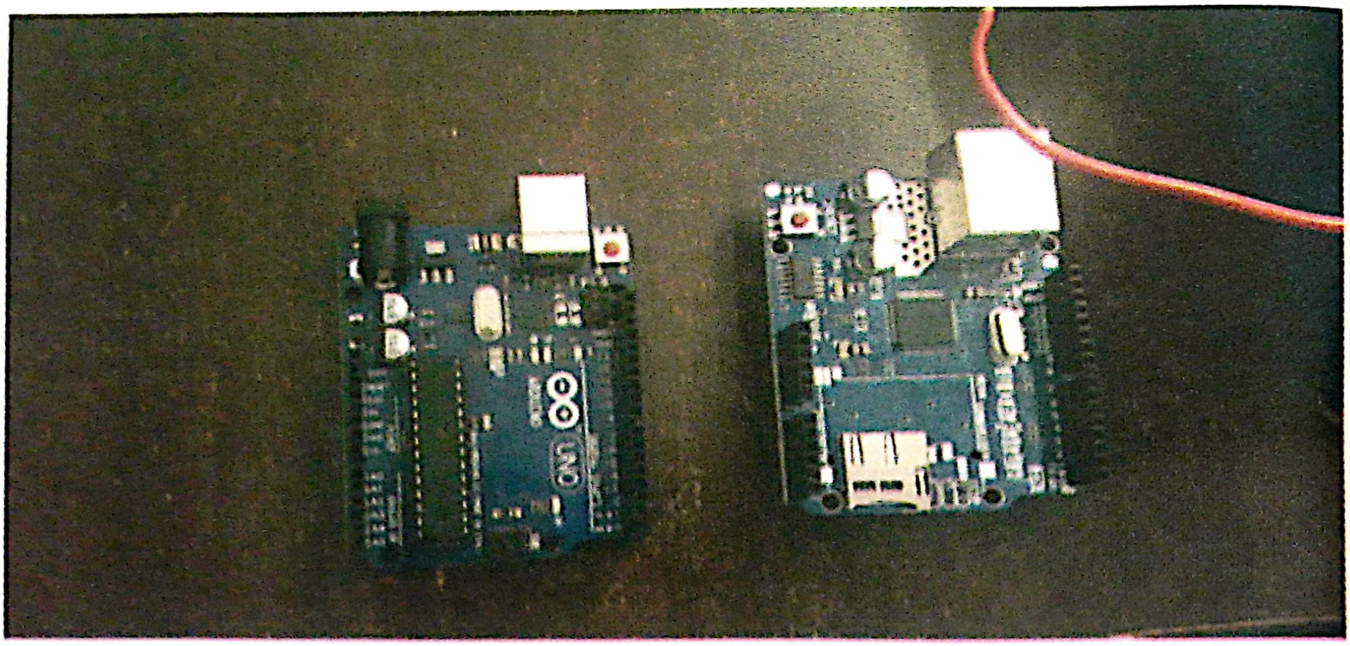


Figure 8 Ethernet shield HanRun HR911105A 19/06

This is designed for network interface card application to meet IEEE802.3 standards including 350uH Min with OCL with 8mADC. It produces les magnetic components to place on PCB, higher reliability and yields

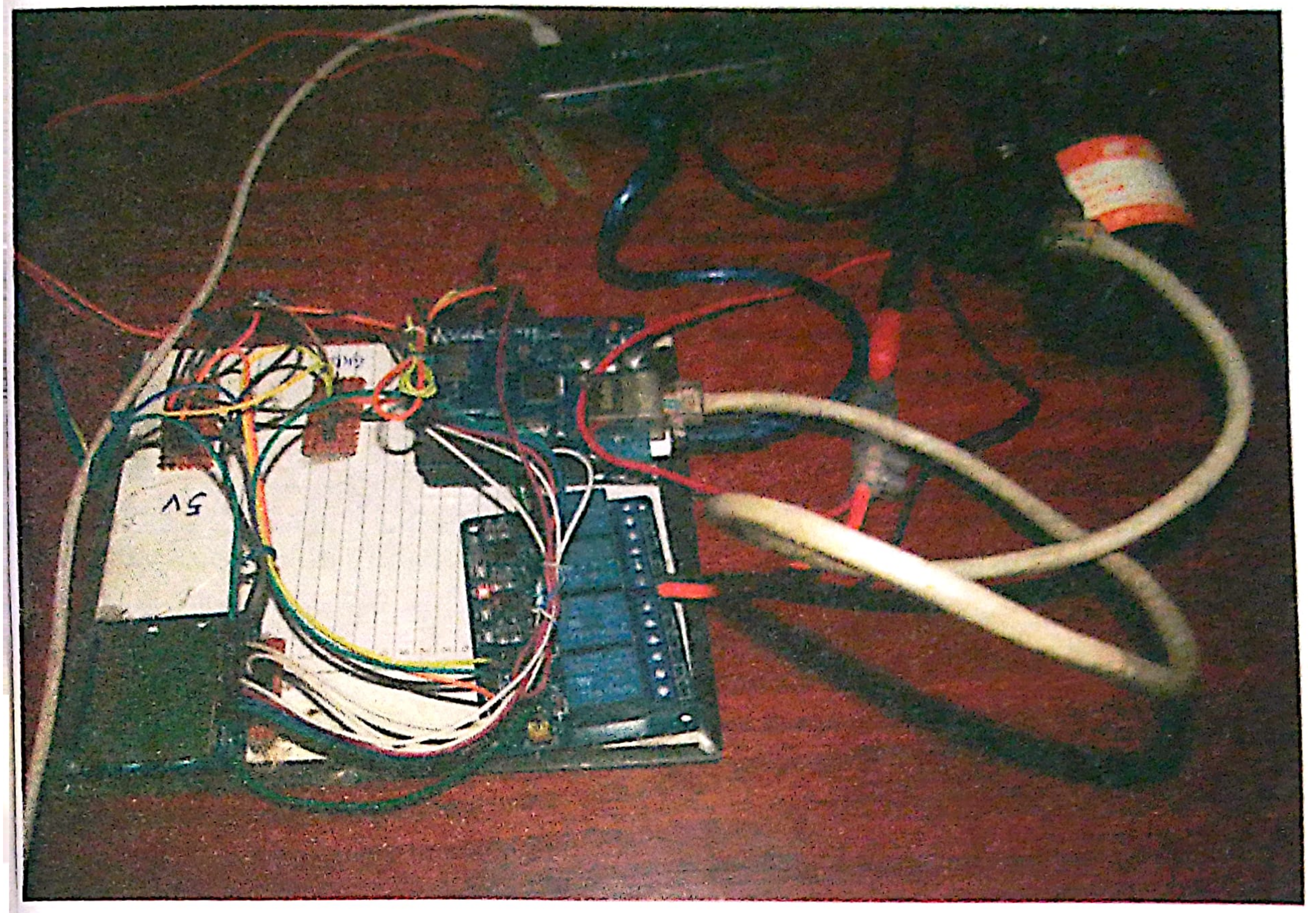


Figure 9: System Connection with Ethernet Shield

DISCUSSION AND RECOMMENDATIONS

Conclusion

It is evidence from this project work that an Automatic Irrigation Control System can be adequately and cheaply made from low cost locally available components and can be used to control multiple irrigation lines

The designed Automatic Irrigation Control System was tested a number of times and certified to control different valves as long as the maximum power and current soil levels does not exceed that of the used relay.

The Automatic Irrigation Control System can also be implemented over Bluetooth, infrared and WAP connectivity without much changes to the design and yet still be able to control a variety of irrigation facilities, Hence the system is scalable and flexible. This project will not only provide convenience to the common man (Pcmag, 2017) but will also be helpful the Elderly and the disabled.

Recommendations

line with the project work and the view of the researched methods and the undertaking in the project design, the following are therefore recommended:

- The University department should help students in gettin components that are not locally available
- Students should be taught how to make embedded systems as th use of computer software in most project work makes it uneconomic and the use of conventional integrated circuits and logic gates make th project work dummy
- The project can be further developed to control more than on irrigation facility at once through the use of short message service te and voice dialing through it though it will be more expensive and w require more circuits.
- The Automatic Irrigation Control System can also be effective be monitored through a mobile app which will be convenient for eas monitoring of the system.

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