DEVELOPING AN AMARINO-BASED WIRELESS WEATHER STATION AND ALERT MESSAGING SYSTEM

By

CATALAN, SANDREA EMIL S.

REYNO, KAREN DIANNE P.

SCHOOL OF ARTS AND SCIENCES

ATENEO DE DAVAO UNIVERSITY

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SANDREA EMIL CATALAN AND KAREN DIANNE REYNO, ATENEO DE DAVAO UNIVERSITY

This system is an approach for a low-cost, accessible, mobile, and easy to install wireless weather station and alert messaging system, using Android and Arduino. It monitors the condition of the physical environment such as pressure, humidity, temperature, light levels, wind speed, wind direction, and rainfall, all in real time mode.
It uses an Arduino microcontroller with the integration of a USB weather board and weather meters. The Arduino Weather Board continuously sends data to the Android device through Bluetooth. The received data is stored in a database of an application that uses the Amarino API. For remote monitoring, there are two ways for a user to get weather data. First, a remote phone requests for the condition of the physical environment by sending an SMS to the Android phone. The Android phone sends the gathered data to the remote phone via SMS. Second, the Android alerts the user about any abnormal conditions like temperature rise, etc. by automatically sending an SMS to the remote phone.
T-test is used to compare the temperature and humidity collected by the system with data collected from a reference weather station. The results indicate that the Mean Absolute Error (MAE) of the temperature is 2.18°C and the MAE of the humidity is 2.66%. With these, results for the comparison of the two weather data have shown minimal error. Its weather real-time monitoring is still within limids to the reference weather station. Also, a comparison of the cost of the some existing systems has been carried out and it shows that the proposed system is a better choice in terms of cost.

Keywords:
Amarino, Arduino, Amarino API, USB Weather Board, SMS, GSM, Bluetooth

ACM Reference Format:
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1. CHAPTER 1

1.1 Introduction

Weather conditions are different around the world even in local area. With this, the importance of weather data is emphasized differently, resulting to some individuals like farmers, scientists and business firms to get their own weather station. Various industries rely on the data collected from personal weather stations to make knowledgeable business decisions.
The cost of the personnel, equipment, and tools used in traditional land-based monitoring system is a factor that hinders the ability to collect suitable amounts of needed data [1]. Also, they are a bit difficult to install and less flexible. As technology advances, wireless weather stations exist that allow tracking weather conditions remotely, providing an accurate, reliable weather monitoring, easy-to-install system. However, they typically cost more than cabled weather stations. [2].

Given that Android phones are a popular and readily available platform [3], the employment of such device, coupled with an inexpensive weather board, offers a low-cost, practical, convenient and efficient wireless weather station and alert messaging system.

Amarino-Based Wireless Weather Station and Alert Messaging System is a low-cost weather monitoring system that interfaces Arduino to Android to monitor the condition of the physical environment such as pressure, humidity, temperature, light levels, wind speed, wind direction, and rainfall, all in real time mode. It allows collection of data from various processes present at distant places. Also, it allows alerts of any abnormal conditions via SMS.

This system uses an Arduino Weather Board with the integration of weather meters. The Arduino Weather Board continuously sends data to the Android device through Bluetooth. The received data is

stored in a database of an application that uses Amarino API. For remote monitoring, there are two ways for a user to get weather data: First, a remote phone requests for the condition of the physical environment by sending an SMS to the Android phone. The Android phone sends the gathered data to the remote phone via SMS. Second, the Android alerts the user about any abnormal conditions like temperature rise, etc. by automatically sending an SMS to the remote phone.

1.2 Background of the Study

While microcontrollers have existed for decades, the Arduino microcontroller is among the first controllers specifically designed to allow anyone execute electronic-incorporated works without knowing the internals of the hardware or software [4]. In this line, Amarino was built to simplify the prototyping process in dealing with Android and Arduino, supporting developers getting quick results. The weather board that comes with ATMega 328 using Arduino library is designed for an automated meteorological data monitoring.

With this, it is already possible to interface the Arduino with Android. However, Amarino itself is broad when it comes to the use of microcontrollers, and very limited when it comes to its methods and functions. This led to the emergence of this study with the research area of interfacing an app using the Amarino API for a wireless weather station.

Thus, the integration of the Arduino Weather Board and an android app using Amarino API removes the gap of these technologies to monitor the condition of the physical environment wirelessly.

1.3 Technology Application Context

Traditional land-based weather monitoring systems are expensive in terms of personnel and equipment, resulting in low levels of data collection in the developing world [5]. Though there are already different prototypes regarding low-cost wireless weather stations and since the use of Android phones, being proclaimed as the world's most popular and availed mobile platform [6], the development of such monitoring system could be an option for a practical, convenient and efficient meteorological data monitoring system.

Arduino is a single-board microcontroller to make using electronics in multidisciplinary projects more accessible. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller. The Arduino Weather Board includes onboard sensors, enabling data to be sent to a computer or data logger.

Amarino is a software toolkit with two main software components: the Android application and an Arduino library. The toolkit might either be used in prototyping projects where sensors, and other devices have to communicate with a phone, or where the phone is utilized to control everyday things wired to the microcontroller.

This study mainly focuses on interfacing an Android app with the Amarino toolkit for a wireless weather station and alert messaging system. Weather data are gathered from the sensors of the Arduino weather board with the integration of the weather meters. The Arduino Weather Board is coded in C programming language, where in the Amarino library is used. The Amarino library is modified (in C++ programming language) in order to meet the needs in the sending the weather parameters. Such weather data are sent from the Arduino to the Android with the use of the Bluetooth Module. The Android app itself receives the weather data and stores it to the database. For the interfacing of the app, the programming language used is Java. Requesting of the weather data and alert messaging happens from the Android to the remote phone. The Arduino Weather Broard is shown in Figure 1, the Weather Meters is shown in Figure 2 and the Bluetooth Module is shown in Figure 3.

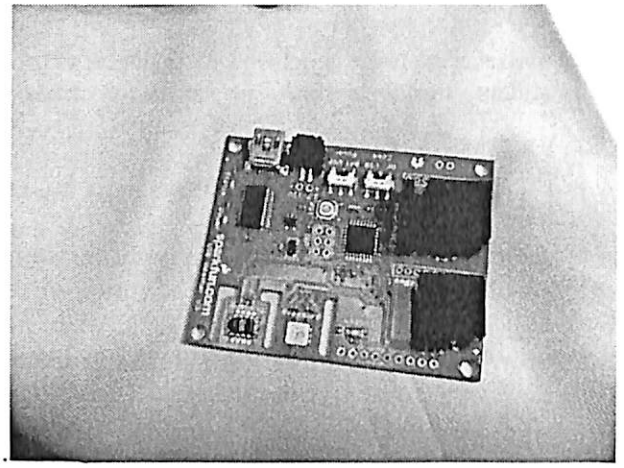

Fig 1. The Arduino Weather Board

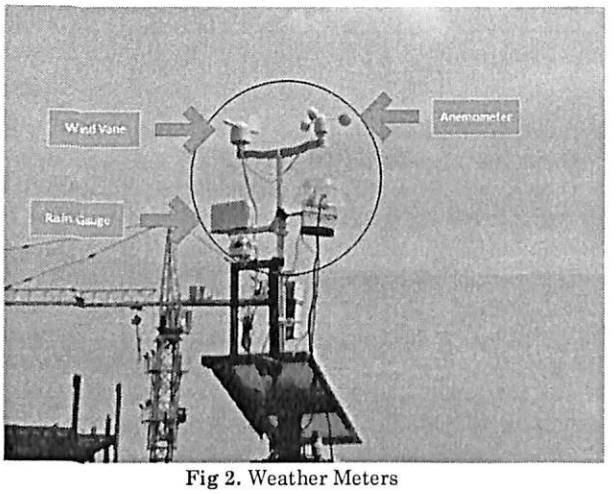

Fig 2. Weather Meters

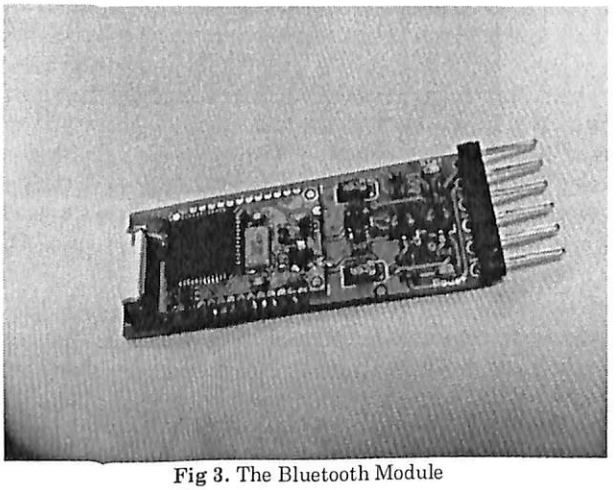

Fig 3. The Bluetooth Module

1.4 Objectives

The general objective of this research is to develop a wireless weather station and alert messaging system using a toolkit that connects an Android-driven mobile device with an Arduino microcontroller.

The following specific objectives are identified:

- To be able to modify the Amarino library in order to send the eight weather parameters
- To be able to use the Amarino library to the Arduino code in order to send the data to the Android app
- To be able to make an Android app using the Amarino API to receive data from the Arduino Weather Board
- To be able to integrate the Arduino Weather Board with the weather meters (Rain gauge, Anemometer and Wind Vane)
- To be able to use the Android App for sending the weather data to the remote phone, so with the alarm message if there exists an abnormal condition, via SMS

1.5 Significance of the Study

In a technological perspective, this study is significant in the field of Information Technology for this study removes the gap between Arduino Weather Board and weather meters, Arduino microcontroller and the Android device. This study extends the functions of the Amarino API by developing an Android App using it. Such researchers who are interested in developing Amarino for future works could make this research as a basis of the study.

Also, this research study is beneficial for Android users to make use of their resources such as making their mobile devices as the console of the data from the sensor. Using Android phones as the console is a practical way because the use of Android phones is mostly availed, being proclaimed as the world's most popular mobile platform [7].

In a contextual perspective, this study is crucial and important for the stakeholders of the firms whose business activities need monitoring of weather conditions in a specific location for the reason that it can be used as an alternative approach for a low-cost wireless weather station. Examples of applications are greenhouses, photographic darkrooms, wine cellars, farming, or any other area of the home where it is important to monitor atmospheric phenomenon. It is also significant on construction places, allowing construction supervisors to move around the site while still having constant access to current weather conditions at the site.

It can also be very beneficial for the farmers especially that this system is low-cost, mobile and efficient. It allows checking the weather condition of the field like if it is raining or if it rained without visiting the place. The requesting and alert of the weather data allow them such because normally agricultural lands are very far from the farmer's house so farmers have to go farm land for weather monitoring that causes inconvenience and fuel consumption(if used any vehicle).

1.6 Scope and Limitations

This study will only focus on the monitoring of the pressure, humidity, temperature, light levels, wind speed, wind direction, and rainfall using a developed Android App as a data logger and alert messaging system. Weather data monitoring only entails a specific area where the weather station is installed. Since Bluetooth module is used for the transmission of data between Arduino and Android, only peer-to-peer communication is allowed in a specific range of 10 meters.

In remote monitoring, the user can send a request to get real-time weather data or the system automatically sends the user an alert for weather abnormalities being set by the user.

This weather station will not focus on weather forecasting. Also, it may not possess the same standard quality as compared to commercialize and expensive weather stations. However, its weather

real-time monitoring is still precise and can be treated as a regular weather station.

2. CHAPTER 2

2.1 Review of Related Works, Literature, & Technologies

The rapid developments of the use of Data Acquisition Systems and Weather Monitoring Systems through different researchers are notable in this present work.

[1]Kaufmann, B. presented his thesis basically consisting of an Android application and an Arduino library entitled Design and Implementation of a Toolkit for the Rapid Prototyping of Mobile Ubiquitous Computing. It explores how the complexity of prototyping mobile ubiquitous computing devices can be reduced with the aid of Amarino, a software toolkit being developed to simplify the prototyping process when dealing with smartphones and microcontrollers in order to support developers getting quick results while focusing on their specific issues rather than spending time for example on implementing communication protocols.

[2]Auto SMS (Autoresponder) is an Android app available for free on the Android market created by Thein Min Naing. It responds to the incoming SMS and missed call automatically and is able to set a schedule to send SMS in future time. It is in line with the proposed system because of its feature that it could automatically reply with the present SMS message for receiving SMS.

[3]The research project made by the Tropical Institute for Climate Studies (TropICS) in collaboration with the Center for Renewable Energy and Appropriate Technology (CREATE), under the aegis of the University Research Council (URC) of Ateneo de Davao University (AdDU) is a Pilot Meso-Scale Meteorological Monitoring Infrastructure. The weather station is based on a gizDuino X microcontroller board, an Arduino-compatible board based on the ATMega1281, for the receiving of data from the sensors using a serial 2-wire interface, and communication with a Real-Time Clock using the I2C interface. The gizDuino X is then attached with a GSM module for the sending of the data (temperature, humidity and rainfall) via SMS to the server and the remote phone every 15 minutes. Data is also stored in a μSD memory card for storage redundancy and backup in case there is no available GSM network service.

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[1] Kaufmann, B. 2010. Design and Implementation of a Toolkit for the Rapid Prototyping of Mobile Ubiquitous Computing. University of Klagenfurt.Faculty of Technical Sciences. Amarino_thesis_kaufmann_2010.pdf

[2] Naing, T. August 2013. Google Play. Auto SMS (Autoresponder). Retrievedfrom https://play.google.com/store/apps/details?id=com.tmnlab.autoresponder&hl=en

[3] Engr. Villanueva, J. 2013. Ateneo de Davao University. Tropical Institute for Climate Studies (TropICS). Pilot Meso-Scale Meteorological Monitoring Infrastructure

[4]Trivedi and Mistry (2009) presented an integration of GPS and GSM for a Weather Monitoring System. The system is using an Arduino GSM modem, GPS receiver and AT Mega 328 microcontroller, resulting in a low cost, easy-accessible, remotely monitored solution for remote areas. It senses temperature, humidity, Carbon Monoxide level, level of alcohol gases and light level where the system is installed. Such data are displayed on LCD within a 10-minute interval. Using the GSM modem, data from the sensors and GPS data are accessible by the users.

[5]Pandya and Shukla (2010) presented a GSM Modem Based Data Acquisition System that helps in gathering data e.g. temperature, rainfall, humidity, etc. from various processes present at distant places. The system uses ATmega 644P AVR microcontroller and GSM modem. This system senses the conditions, and a message is sent to a mobile number using SMS on LCD within a 10-minute interval, enabling the operator can monitor the signals from anywhere. The GSM modem is connected to microcontroller using RS232 interface. If an SMS is sent to the GSM modem, the GSM modem receives the data and sends to the microcontroller. The microcontroller then processes the data and sends information to the mobile number. The data collected is automatically transcribed into a data base and stored in a PC. For the user interface, a 16X2 LCD is provided.

[6]Yawut and Kilaso (2010) presented a system that may be used to prevent enormous damage from natural disasters. The use of a wireless sensor network based on Zigbee (or IEEE802.15.4) standard and an arduino microcontroller is utilized as a weather station network that sends the weather information and disasters' alerts. The advantages of wireless sensor networks are taken well into account as they have the ability to send signals over far distances by using a mesh topology, in which data transfers occur and power consumption is kept into minimum.[7]G.S. Nhivekar and R.R.Mudholker presented adesign and implementation of ATMEL AVR Atmega32 microcontroller based embedded system for data logging and remote monitoring of environmental parameters like temperature and humidity. The microcontroller provides eight channels ADC (Analog to Digital Convertor) which can be used in 10-bit mode for data acquisition. The exchange of the information in the system is through SMS to the user's mobile phone. The system offers data-logging facility in which data can be moved to a PC having a GUI program for analysis or printing purposes. Using the usual mercury thermometer and masons hygrometer, the observed data were compared and concluded that there's a very close agreement between the data collected by the system and that measured by already available and calibrated systems. This system can be useful for studding behavior of industrial and home processes application having multiple parameters.

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[4]Trivedi, K. and Mistry, D. 2012. Integration of GPS and GSM for the Weather Monitoring System.BuletinTeknikElektrodanInformatika(Bulletin of Electrical Engineering and Informatics)Vol.1, No.3, September 2012, pp. 185~190 ISSN: 2089-3191.

[5]Pandya , V. and Shukla , D. 2012.GSM Modem Based Data Acquisition System . International Journal Of Computational Engineering Research (ijceronline.com) Vol. 2 Issue 5.

[6]Yawut, C.and K. Sathapath. 2012. A Wireless Sensor Network for Weather and Disaster Alarm Systems. International Association of Computer Science & Information Technology (IACSIT)