An Embedded System based Autonomous Intelligent Farming System

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***Abstract*—This paper proposes an Embedded system for Improvement in agriculture specially In the barren field of our country. We approached the local landlords and agreed on certain digitally enhanced facilities that could be offered by an embedded system. This paper describes the problem and analyzes the way it was formed along with a respective literature review on the subject. We present the platform we used and we explain our design methodology decisions as regards the system's main functional parts. Hardware and software requirements are identified as we move towards a power-efficient, embedded system that uses sensors to acquire critical environment measurements and inform agriculturists or farmers through the GSM Short Message Service (SMS). The hardware design and the respective software structure are presented, leading to a proposal about creating a specialized board. The code structure is explained and the main parts of the system are discussed. Finally, conclusions are stated and a possible future full-scale single PCB, governed by the principles of Open Source Hardware, is considered.**

***Keyword*- Embedded systems, Agriculture, smart farming.**

I. INTRODUCTION

The penetration of smart computing devices into everyday life is nowadays a given fact. Terms like *ambient intelligence* and *ubiquitous* or *pervasive computing* describe the trend of embedding information processing techniques into our work, leisure and life transparently and yet effectively. In this context, " Fertility Improvement" comes as a natural scientific activity that aims to serve both humans and their environment simultaneously. The use of smart, easy-to-use, transparent, computing devices can prove highly beneficial in maximizing the products of cropping systems, while maintaining a sustainable and eco-friendly farming practice.

This paper presents an attempt to create a smart embedded system that will aid agriculture in a cost effective and flexible way. We decided to take up this effort because the techniques of agriculture in our country are very poor, so the aim of working on this project is to promote an agriculture activity which bases much of our country economy and trade. We, therefore, contacted agriculture representatives and requested information about the process of smart agriculture along with its respective problems.

Namely, we addressed the problem through a design process, which is presented in Fig.1 and is divided in seven phases. Initially, we had extensive meetings with agriculture representatives along with three farmers who have large experience in farming and grain production. Consequently, we consulted two agriculturists with expertise in wheat production and aging. The acquired details were significant and quite informative. All the respective parties agreed that a frequent information update about weather conditions in the field areas is of absolute necessity. This update should be carried out every hour and it should include the ambient temperature and humidity, because these two factors have a great impact in most of the thereafter stages.

Furthermore, these two measures, apart from being instantly transmitted, they should as well be properly processed in order to formulate a comprehensible suggestion message that will also be transmitted to respective users. This message should contain all the necessary suggested actions that a user of variable knowledge and experience will be able to understand and carry out in time. The whole system aims to simultaneously support new and old farmers and agriculturists, regardless of their skills in farming or competence in technology. In fact these two factors are generally conflicting. The more experienced a farmer is, the older he/she is and the less fluency he/she has with technology. On the other hand, the younger the farmer, the more comfortable he/she feels with technology but the less experience he/she has in farming.

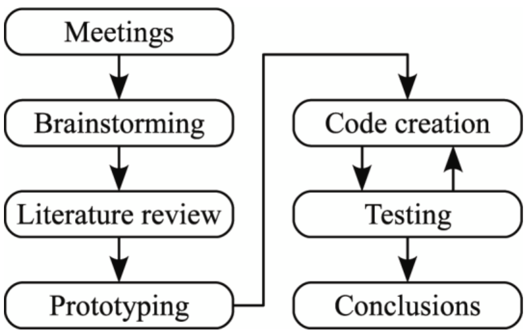

Figure1. Design process

During the brainstorming phase, we considered various solutions that could meet the diverse initial demands and we examined the potential platforms and hardware equipment that could be utilized. Our final decisions are presented in the second and third sections of this paper.

As regards similar efforts, NASA proposed a prototype that refers to the creation of a digital farm system that transmits information about agricultural activities. Other cases include RF and WiFi transmission of sensor-acquired data [3], [4], [5]. In the SMS type of communication we can identify the *botanicals* initiative [6] [7], while an effort that utilizes the Arduino platform is mentioned in [8]. In Greece, similar attempts are carried out by the company “inventor engineering” [9] and by a joint five-partner research project called “Hydro Sense” [10].

II. PROBLEM DECISIONS AND DESIGN METHODOLOGY

Our system is based upon the Arduino platform (http://www.arduino.cc), which is an open-source electronics prototyping board (Fig. 2). It features an Atmel AVR 8-bit micro-controller (ATmega328P) and a number of easily accessible digital and analog I/O pins. Namely, the board provides 14 digital input/output pins, 6 of which can be used as PWM outputs, and 6 analog input pins. It can be programmed and powered through a USB port and power can also be provided through a DC-in jack.

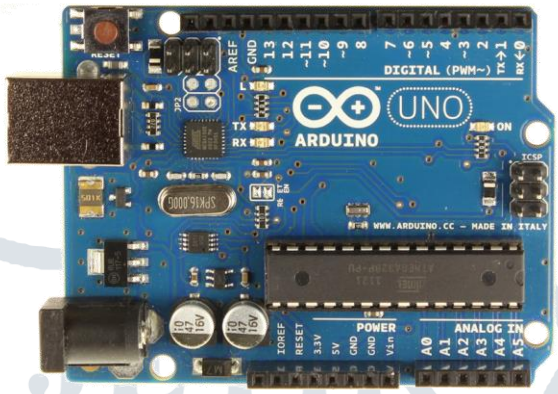

Figure2. Arduino Uno

This board has become widely popular in communities that are not only technology oriented. A vast amount of information about it can be found over the Internet and diverse projects have been built around the Arduino board. These projects range from infrared controlled helicopters [11], medical jackets [12], interactive artwork [13], autonomous vehicles [14] and sensor networks [15] up to smart home applications [16], undersea robots [17] and 3D printing.

Apart from its popularity, the Arduino Uno board, that we selected, is characterized by high versatility and low power consumption. These were the key factors for its selection along with its open hardware philosophy that we also aim to follow. In particular, our initial requirements regarding hardware and software can be listed as follows: easy and direct prototyping, user-friendly programming environment, hands-on debugging abilities, low power demands, significant user support and access to all hardware and software details, straightforward product Packaging, ability to make one compact PCB, low manufacturing costs and as much fault tolerance as possible.

These requirements were largely satisfied by a system that would combine the Arduino Uno platform along with commercially available *shields* and distinct electronic parts. Shields are add-on boards that can be plugged on top of the Arduino PCB using the female connectors appearing in Fig. 2 and extending its capabilities. Among the various existing shields we identify their common philosophy: they are easy to mount and cheap to produce. As a result, one of our targets is to build a new shield that will be directly oriented towards smart agriculture.

Returning to the problem in hand, we decided to combine the Arduino Uno platform with a shield that would allow Short Message Service (SMS) communication. On top of that, a user interface must be created, in order to allow the input of some initial data, along with sensors that will interact with the farming environment.

III. HARDWARE DESIGN AND SOFTWARE STRUCTURE

Apart from the Arduino Uno board, we used the following parts:

User information from the system: We utilized the GPRS shield (http://seeedstudio.com/wiki/GPRS_Shield), which communicates through the GSM digital cellular network and allows the transmission of SMS messages. It can be controlled through UART and simple AT commands allow its full configuration and functioning. This GPRS shield is much alike an ordinary cellular phone but without the common phone to user interface.

Data view: We chose to present data to the user through a 2-line, 16-character LCD screen (http://www.sparkfun.com/products/9395). This particular module is based on a PIC 16F88 micro-controller and allows a 9600 bps serial communication over a single line. The preinstalled firmware allows the adjustment of backlight brightness and power state through appropriate commands.

Environment sensing: We used the Sensirion SHT15 humidity and temperature sensor (http://www.sensirion.com/en/01_humidity_sensors/03_humidity_sensor_sht15.htm) on a breakout board to ease cable access and manipulation. The SHT15 is a high precision, stable and low cost sensor, which is very sensitive and straightforward to use.

Data entry: We were asked to keep the actual data entered by the user to an absolute minimum. The product is directed towards practitioners that wish to have a fully automated box with as little interaction as possible. As a result, we agreed to have only an initial phase of data entry: phone number and current date. This simple, one-time setup can be satisfied by mere push-button, simultaneously keeping energy consumption to a low level.

The assembled prototype appears in Fig. 3. In the upper part of the figure we have the stacked Arduino Uno board (Back) and the GPRS shield (front). A 9V battery powers the system and the SHT15 sensor breakout board appears in the center part along with the LCD screen. A small breadboard aids the connectivity of wires and houses the Push-button and a Pull-down resistance.

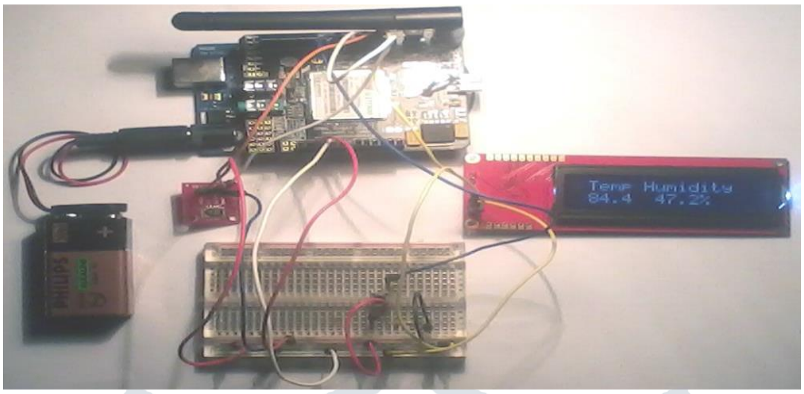

Figure3. The Prototype Design.

Moving on to the software of the system, we state that we used the Arduino development environment, which is actually based on *Processing*, an open source language and development tool that follows the object-oriented paradigm Our code would be straightforward and specific.

The SHT15 sensor is being polled every 3 seconds in order to acquire temperature and humidity measurements, which are subsequently displayed on the screen. Through a series of decision structures we would be constructing a moderate expert system, based on the advices we received from agriculturists. These structures formulate a respective message that can be transmitted to the farmer on an hourly or monthly time schedule. These messages can be warnings about sudden and severe weather changes, advices for a required cropping action or simple notification postings about the current state and health of the farm.

The code, along with all the hardware design models are provided through an open-source governed license. Our intention is to follow the open philosophy that rules both the hardware and the software of the Arduino attempt in the spirit of open source hardware that gains increasingly more popularity.

Post processing could be allowed in order to let the users tide-up and formulate their product according to their taste and housing needs. Fig. 5 presents our respective project design of Fig. 3 inside the Fritzing environment. The similarity of look-and-feel could prove user-friendly.

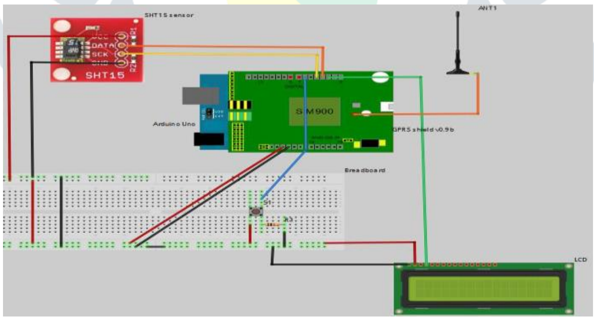

Figure5. Fritzing design.

The purpose of this shield-making decision is to allow the easy expansion of the system with even more stackable shields that will permit the increase of the potential functionality. Specifically, a WiFi shield could allow an alternative communication path and a Micro SD shield could enhance the storage size for vast data archiving. Finally, a motor shield could drive diverse modules that would aid the cropping procedure.

In order to materialize this shield-stacking technique, we would carefully design our PCB in such a way that all available I/O ports would still be offered in female connectors and we would attempt to occupy as little digital ports as possible so as to leave available ports for other future shields as well.

IV. CONCLUSIONS AND FUTURE WORK

Smart digital farming can prove useful in agriculture. Our first experiments in real-life conditions seem to prove our initial expectations and our cooperation with farmers and agriculturists will provide even more feedback for program enhancements and code fiddling. The required manufacture and infrastructure costs were kept low, taking under consideration that we are still in the prototype phase, and simplicity was adequately achieved, although this often comes opposing to advanced user interaction abilities.

Apart from raw labor cost savings, we expect our system to aid in water management optimization, better soil nutrition, decreased fertilization, farming automation, improved maintenance reaction times, food-chain monitoring and statistical data dissemination. On top of that, we expect this automation to ease the risks taken by farmers and allow more young people to invest in farming activities, knowing that agricultural skill and advice can be at the their disposal uninterruptedly through simple digital communication means.

The shield that we intend to produce will not be our final step of this effort. We have plans to design a full-scale single PCB that will house all the necessary parts in one electronic layer. This idea is scheduled to become real after we have extensively tested our first version product, in order to fully conclude in all the required hardware and software modules that will materialize the farmers' and agriculturists' demands. To be more specific, we will test our shield in combination with other available shields, so as to reach a conclusion about the right trade-off of complexity and cost against usability and expected benefits.

When we reach our final hardware setup we will design a single PCB that will house the Arduino board, our respective modules and all the required shields' functionality. We have already started to design such a board, using the open-source electronic design automation suite KiCAD (http://kicad.sf.net). Since most of the players in the Arduino "universe" follow an open philosophy, we were able to find vast hardware information in order to build our own schematic and PCB designs. This attempt will also lead to an open-source hardware product that will primarily aim to help smart farming but will easily be extended to other cropping activities as well.

V. REFERENCES

[1] Himanshu Pandey Secretary of Core Team Member & Counseling Service. Ph.D Scholar (Design Programme), IIT Kanpur.

[2] R. Harberts, L. Roelofs, H. K. Ramapriyan, G. McConaughy, C. Lynnes, K. McDonald and S. Kempler. (2003, Sep.). Intelligent Archive Visionary Use Case: Advanced Weather Forecast Scenario. NASA white Paper prepared for the Intelligent Data Understanding program. [Online]. Available: http://daac.gsfc.nasa.gov/intelligent_archive/ VirtualFarms_v1.pdf

[3] V. Singh. (2010, May). Wireless Monitor. Parallax 2010 RF design contest winner. [Online]. Available: http://www.parallax.com/ Portals/0/Downloads/contest/2010rfdesign/VineyardFullReport.pdf

[4] S. Galmes. "Lifetime Issues in Wireless Sensor Networks for Vineyard Monitoring," in Proc. IEEE International Conference on Mobile Adhoc and Sensor Systems (MASS), 2006, pp. 542-545.

[5] J. Lloret, I. Bosch, S. Sendra and A. Serrano. "A Wireless Sensor Network for Vineyard Monitoring That Uses Image Processing," Sensors, vol. 11, (6), pp. 6165-6196, 2011.

[6] R. Faludi, K. Hartman and K. London. Botanicalls. [Online]. Available: http://www.botanicalls.com

[7] D. Ackerman. (2011, Nov.). Your Begonia is Texting You. [Online]. Available: http://opinionator.blogs.nytimes.com/2011/11/12/your-begoni a-is-texting-you

[8] S. Sharp. (2011, Jul.). Growing Food with Open Source. Presented at O'Reilly Open Source Convention (OSCON). [Online]. Available: http://assets.en.oreilly.com/1/event/61/Growing Food with Open Source Presentation.pdf

[9] Inventor Engineering Co. eKo Wireless Sensor Network for Cultivation Nonitoring and Control. [Online] Available: http://www.inventorengi neering.gr/apps-environmental.shtml. [10] Goulandris Natural History Museum, Benaki Phytopathological Institute and Benaki Phytopathological Organization, University of Thessaly, National Agricultural Research Foundation and Agricultural University of Athens. The Hydrosense Project. [Online]. Available: http://www. hydrosense.org .

[10] S. Divakar. "Multi-colored line following and obstacle avoiding helicopter," in Proc. 3rd International Conference on Electronics Computer Technology (ICECT), 2011, pp. 135-139.

[12] W. Chen, S. T. Nguyen, R. Coops, S. B. Oetomo and L. Feijs. "Wireless Transmission Design for Health Monitoring at Neonatal Intensive Care Units," in Proc. 2nd International Symposium on Applied Sciences in Biomedical and Communication Technologies, 2009, pp. 1-6.

[13] Y. C. Yang, S. T. Wang, Y. J. Tseng and H. C. K. Lin. "Light up! Creating an Interactive Digital Artwork based on Arduino and Max/MSP Design," in Proc. International Computer Symposium (ICS), 2010, pp. 258-263.

[14] C. Hockley and B. Butka. "The SamarEye: A Biologically Inspired Autonomous Vehicle," in Proc. 29th IEEE/AIAA Digital Avionics Systems Conference (DASC), 2010, pp. 5.C.1-1-5.C.1-9.

[15] N. W. Bergmann, M. Wallace and E. Calia. "Low Cost Prototyping System for Sensor Networks," in Proc. 6th International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2010, pp. 19-24.

[16] A. M. A. H. Al-Kuwari, C. Ortega-Sanchez, A. Sharif and V. Potdar. "User Friendly Smart Home Infrastructure: BeeHouse," in Proc. 5th IEEE International Conference on Digital Ecosystems and Technologies Conference (DEST), 2011, pp. 257-262.