ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 5, November 2017

One solution for private Raspberry Pi based weather station for agriculture

Emir Pecanin, Milos Ilic, Petar Spalevic, Mladen Veinovic, Zoran Todorovic
State University of Novi Pazar Serbia,
Faculty of Technical Science Kosovska Mitrovica Serbia,
Faculty of Technical Science Kosovska Mitrovica Serbia,
Singidunum University Belgrade Serbia,
Higher Technical Professional School Zvecan Serbia.

***Abstract*— This paper addresses the challenges associated with the construction of low cost weather station equipped to measure parameters vital for smart agriculture. As high number of farming related problems are directly correlated with weather conditions in the target area, private weather station proves to be an important tool as it can be used for monitoring the climatic conditions on the arable land. Solution for private weather station that is proposed in this paper is based on the use of Raspberry Pi board computer, weather sensors and soil sensors.**

***Index Terms*—GSM module, Raspberry PI, Smart agriculture, Radio waves.**

I. INTRODUCTION

The modern agriculture is based on knowledge of meteorological parameters, and weather forecasting. Weather forecasting is the application of science and technology to predict the state of the atmosphere for a given location [1]. Using weather monitoring systems, farmers and agricultural experts could collect the information about different weather parameters (temperature, humidity, wind speed, rainfall, and etc.), and according to real-time and historical data they could predict precise timing for different farming activities. Some of the key activities dependent on weather conditions are chemical protection and protection against frost. These two conditions can significantly reduce or even completely destroy the quantity of products in one production year. However, listed problems can successfully be avoided with adequate treatments at the right moment.

In order to collect weather parameters from arable land and their production fields, farmers need to have well planned system of strategically positioned meteorological stations so as to cover targeted area. Each station has coverage area that is most often conditioned by the configuration of the terrain and the actual purpose of the meteorological station. Along with position of meteorological stations, such systems must satisfy a number of other different requirements.

On the one hand, station needs to be well equipped with different kinds of sensors, and must have the ability to send data to the base station. On the other hand, there are limiting factors such as power supply and natural obstacles that need to be solved. The price of commercial meteorological station equipped with the necessary sensors is one of the limitation factors too.

Almost all requirements regarding the creation of a meteorological station can be met with the use of electronic components available on the market. One solution for creation of private weather station is presented in this paper. Proposed solution is based on the use of Raspberry Pi computer, meteorological sensors and soil sensors. The proposed station will be equipped with all sensors that can be used in order to improve agricultural production. Along with the solution proposition, the paper gives an overview of the advantages and problems in the realization of the mentioned meteorological station.

The paper is organized as fallows. Second section gives an overview of similar researches. Third section presents our solution for Raspberry Pi based weather station. In the fourth section advantages and problems in the realization and use of such station are described. Main conclusions and ideas for future research are presented in fifth section. At the end of the paper list of the references is presented.

II. RELATED WORK

A vast number of systems for weather monitoring are available on market these days. The main difference is in the targeted coverage area and whether the system is created for real time monitoring of a whole city or state, or for a small area. In one of the researches, authors created real time monitoring system for small area based on Arduino micro-controller. Three sensors are used to measure weather factors such as temperature, humidity, light intensity, dew point and heat index in controlled environment [1]. The DHT11 sensor is used in order to provide the current temperature and humidity readings. Dew point and heat index are derived or calculated from the reading obtained from DHT11 sensor. The LM35 temperature sensor is used for additional temperature readings. For the measurement of atmospheric pressure and the temperature BMP180 sensor is used. LDR (Light Dependent Resistor) is used for measurement of light intensity. The gathered information is used to determine the optimal conditions for plants to grow.

Authors in [2] present system for collection and sending the data on the remote side of the meteorological station and modules for receiving, storing and displaying the results using web interface on server side. Weather station includes rain collector, temperature sensors, air humidity, anemometer, UV sensors and etc. GSM connection is used in the process of data transmission. Data were transmitted hourly after each measurement.

Comparison of measuring equipment accuracy between commercial and private weather station is presented in [3]. Researchers designed weather station and deployed on the Edamame farm. The installed low cost weather station was equipped with air temperature, relative humidity and wind direction sensors. Data collector and transmitter unit consisted of PIC24FJ64 microchip as a main central computing unit, and meteorological sensors supplied by Warf Corporation Co., Ltd. In this research, for data transmission from the data collector unit to the base station the low cost radio transmission module called Xbee was used. The XbeePro S2 module is based on IEEE802.15.4 standard which providing 256 kbps bandwidth over 2.4 GHz frequency bands and has a transmission range of 1.6 km line of sight. For the base station Raspberry Pi 2 model B was used. Meteorological data collected from designed weather station are compared with the data collected from commercial Davis Vantage Pro2 weather station that was installed at the same farm. The obtained results showed that private low cost weather station is equivalently efficient as commercial weather station in the process of measuring various weather parameters.

III. SYSTEM COMPONENTS

A. Raspberry Pi board computer

This computer is the main component of the meteorological station that controls the operation of all sensors [7]. Raspberry Pi is a small-size computer with an operating system on the memory card [3]. In addition to its small size and low price, the features of this computer are comparable with the characteristics of personal computers. For the purpose of this weather station creation the Raspberry Pi 3 Model B will be used. The Raspberry Pi 3 Model B is the third generation Raspberry Pi [8]. This powerful credit-card sized single board computer can be used for many applications. Characteristic for the third generation of this computer is that it works on the GNU / Linux platform as well as on the Windows 10 platform. In this way, it provides a good basis for eventual expansion and communication with other devices. Connecting the sensor to this computer will be done through the general purpose input pins (General Purpose Input / Output pins - GPIO) located on the computer board. There are forty GPIO pins on the Raspberry Pi board. Sensor identification during the implementation of communication with the Raspberry Pi device will be done based on the unique serial number of each sensor.

B. Temperature sensor

One of the characteristics of the temperature is its oscillations during the day. Some of the agriculture processes are highly dependent on daily temperatures. For the temperature measurement in outside conditions DS18B20 sensor is selected. This is pre-wired and waterproofed temperature sensor. It is perfect for outside environment such as the agricultural field. It is a digital sensor which allows signal propagation over long distances without any degradation. Another key advantage is that it requires only one digital pin for the communication with Raspberry Pi or any other microcontroller. Based on the fact that each sensor has a unique 64-bit ID created by the manufacturer, and based on digital communication between sensor and microcontroller, multiple sensors can be connected to the same pin. It can measure temperature in the range of -55 to +125°C. The accuracy of this temperature sensor is ±0.5°C when the temperature is in the range from -10°C to +85°C. When the temperature is out of this range accuracy is lower. This sensor will be set at 1m height from the ground level.

C. Humidity sensor

In order to measure relative air humidity Honeywell HumidIcon™ digital Humidity/Temperature sensor HIH6000 series is selected. This sensor is digital output-type relative humidity (RH) and temperature sensor combined in the same package. It will be set at the 0.5m height from the ground level [4]. Accuracy of relative air humidity measurement is ±4.5%, and the temperature measurement accuracy is ±1.0°C. It can measure temperature in the range of -40 °C to 100 °C. The sensor goes into sleep mode when it is not measuring parameters, in which case it consumes only 1 μA of power. In the full operation mode sensor consumes 750 μA of power. This is especially good functionality for the systems without a constant power supply that work on battery. In those cases sleep mode reduce power supply size, and maximizes battery life.

D. Rain gauge sensor

It is important that private weather station used in agricultural has the possibility to gather information about the amount of rainfall over one day period. Because of that we decide to include rain gauge as one of the key components in our weather station. A rain gauge provides a measure of how much rain has fallen over a given time period. Selected rain gauge is basically a self-emptying tipping bucket. Rain is collected and channeled into the bucket. Once enough rainwater has been collected the bucket will tip over, the water will drain out from the base, and the opposite bucket will come up into position. Based on technical documentation each 0.2794 mm of rain causes one momentary contact closure that can be recorded with a digital counter or microcontroller interrupt input. Signal collected from the input will be converted into meaningful measurement with the use of implemented solution on the Raspberry Pi.

E. Wind speed sensor

For the measurement of wind speed anemometer wind sensor will be used. This wind speed sensor is composed of a shell, three wind cups and a circuit module, which is made of aluminum alloy material. The whole sensor has a high strength, weather resistance, corrosion resistance and water

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 5, November 2017

resistance. These materials provide durability of the device, long-term use of the instrument, and the accuracy of the wind speed collection. The accuracy of this sensor is ±1m/s. The starting point of the measurement is at the wind speed of 0.2-0.4 m/s. Maximum wind speed that can be measured is 32.4 m/s. Maximum outside temperature on which this sensor can work is +80°C, and it is resistant to direct sunlight.

F. Leaf wetness sensor

Leaf wetness has been studied extensively for decades, especially by the plant pathology and agricultural meteorology communities because some plant diseases require the presence of free water on a crop canopy for infection [5]. The Decagon Devices, Inc. leaf wetness sensor will be used to detect the presence of surface moisture on foliage and calculate the duration of wetness. When moisture is present, the sensor detects an electrical resistance change between the gold plated elements of the grid. The sensor's thin (0.65 mm) fiberglass construction closely approximates the overall radiation balance of a healthy leaf, so moisture will condense and evaporate from the sensor at the same rate as it would on a normal leaf [6]. It can operate in the temperature range between -40°C to 60°C.

G. Soil sensor

Soil moisture sensors measure the amount of water in the soil to maintain consistent and ideal soil conditions for plants. The solution for soil moisture measurement will be based on Octopus Soil Moisture Sensor. This sensor uses two probes to pass current through the soil, and then it reads resistance to get the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly because of more resistance.

IV. ADVANTAGES AND POSSIBLE PROBLEMS IN THE REALIZATION OF THE SOLUTION

A. Advantages of private weather stations over commercial ones

Weather stations used in agriculture help to understand the interactive influence of climate factors on the amount of yield. The main differences between commercial and custom made (private) weather stations are in the same time the main advantages of private weather stations.

Equipping sensors can be taken as the first advantage of private meteorological stations in comparison to the commercial. Along with usual sensors that are in use for climate monitoring, private stations intended for the use in agriculture can be equipped with different types of other more specific sensors. Some of these sensors are leaf wetness and soil moisture sensors mentioned in previous section. Beside these sensors weather stations can be equipped with radiation frost sensor. Such a sensor is the main pre-order for successful protection against frost.

One of the huge advantages of private weather stations is the price. The price of commercial weather stations that can be purchased on the market is in the range of 3000-6000 euros. For the small agriculture company or family farm this price is too high. The price of the proposed solution is far below the price of commercial weather stations. This is not conditioned with the quality of the sensors because as we have seen the accuracy of these sensors is more than satisfactory for the application in agriculture. Because of lower price farmers have the ability to set up a higher number of weather stations correctly deployed on their production areas. In this way they can cover larger surface, especially if the weather conditions are different on the different parts of the production areas.

Private weather stations can be connected with different irrigation or anti-frost systems which is one more advantage. In this way software solution which is run on the Raspberry Pi can initiate or interrupt the operation of the watering system or some other systems, based on predetermined values for different weather parameters. For example based on amount of the water in the soil measured with soil sensor, irrigation system can be interrupt. In this way, on the one hand, water consumption is reduced, while on the other hand, the possible harmful effects of excessive water on the root of the plant are prevented. Based on the measured temperature, the anti-frost system can be started at a convenient time during the night without the action of the farmer. In this way the plant species in the production field will save their yields.

B. Possible problems in realization

In most of the cases open agriculture fields are not electrified. One of the problems of proposed solution is constant power supply. Continuous power supply can be provided with a solar panel and rechargeable batteries. Moreover harvesting energy from the sun to support weather station is long term cost saving operation. The size of the panel will depend on the daily power consumption. Raspberry Pi power consumption and power consumption of all sensors the user wants to be set up must be taken into account. The good practice is that panel size needs to be adequate to produce 2-3 times as much power as daily power consumption on a good day. The Raspberry Pi requires a stable 5 Volt DC power supply, but for economical solar charging it is best to use a 12V charging solar panel and a 12V deep cycle or leisure battery. In order to get the 5V from the more then 12V of the battery, power regulator need to be used. It is possible that a cheap linear regulator such as the common L7805 can be used to bring the 12V from the battery down to the 5V for the Raspberry Pi, but such a regulator will be only 40% efficient with these voltages resulting in 60% of solar generation being wasted at heat in the regulator. Instead a switching regulator should be used which will give much better efficiency. The last part of solar power system is a solar charge controller. This device stops the battery from being over-charged in the summer months when the Raspberry Pi is using less battery charge than the solar panel is capable of putting into the battery.

Remote access and data transfer from the weather station to the base station is one additional problem that needs to be solved. One of the possible solutions is the use of wireless sensor networks. The key parameters that have to be

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 5, November 2017

considered are the distance between the base station and the meteorological station, as well as the physical barriers that can cause interference. In the last couple of years, Zigbee technology has been increasingly used in smart agriculture because of its advantages in topology, flexible architecture, lower power consumption, and lower price.

This technology is based on IEEE 802.15.4 standard. Architecture defines two layers, namely the physical layer and the medium access control sub-layer [9]. Some of the modules appropriate for this solution like we mentioned earlier provide 256kbps bandwidth over 2.4GHz frequency bands and has a transmission range of 1.6 km line of side [3]. This transmission range can be sufficient for use in transmitting data to the base station receiver. Additionally amplifier needs to be installed between transmitter (on meteorological station) and receiver (on base station).

Another solution for communication between weather station and base station is GSM network. Something similar is used in [2]. In this case the use of GSM technology provides possibility of data transmission over wide geographical areas. For example SIM900 GSM module is complete Quad-band GSM/GPRS that supports voice uses, SMS, and Data application. Besides different communication application possibilities this module is low power consumption.

V. CONCLUSION

The use of different sensor networks, information and communication technologies in order to improve agriculture have developed precise agriculture as a special area of agriculture. Climate is one of the most important environmental parameters that determine the yields in the production area. Because of that each farmer should have its own weather station. Proposed solution of weather station from one side can be fabricated for a relatively small amount of money, and from the other side it is well equipped with all the sensors needed. In addition, this solution offers a lot of extensibility with additional measuring devices or replacement of existing sensors with other sensors. Also, the solution is easily portable due to the fact that it is not dependent on the electrification network.

Our plans for future work and research are pointed into practical testing of the whole system. Our custom meteorological station will be installed in the agriculture field. Practical testing will be conducted so as to improve solar power and data transmission. After installing and establishing communication, a comparison of the readings from the installed meteorological station and values obtained from a conventional station will provide us with an insight about the weaknesses (and strengths) of the system. This will be the key point for future enhancement.

REFERENCES

[1] K. Karthik, T. Suraj, K. Lokesh, and P. Arun, "Arduino Based Weather Monitoring System", International Journal of Engineering Research and General Science, vol. 3, issue 2, March-April 2015, pp. 452-458.

[2] V.R. Minic, P.I. Lugonja, and V.S. Crnojevic, "A complete system for remote collection of meteorological data", in Proc. of 19th Telecommunication forum – Telfor, Belgrade, Serbia, 2011, pp. 20-22.

[3] T. Sonam, S. Satetha, P. Theerapat, K. Teerakiat, "Low Cost Weather Station for Climate-Smart Agriculture", in Proc. of Knowledge and Smart Technology (KST), Chonburi, Thailand, 2017, pp. 172-177

[4] [4] Honeywell HumidIcon™ Digital Humidity/Temperature Sensors, Available: https://www.tme.eu/en/Document/517dcb61fff63363578e5a4de89c198f/HIH6000.pdf

[5] R.L. Tracy, "Leaf wetness: implications for agriculture and remote sensing", Ph.D. dissertation, Iowa State University, Ames, Iowa, 2011.

[6] Decagon Devices, Inc., Dielectric Leaf Wetness Sensor Operator's Manual, Available: http://manuals.decagon.com/Manuals/10386_Leaf%20Wetness%20Sensor_Web.pdf

[7] Raspberry Pi Hardware Available: https://www.raspberrypi.org/documentation/hardware/raspberrypi/README.md

[8] Raspberry Pi 3 Model B Technical documentation, Available: http://docseurope.electrocomponents.com/webdocs/14ba/0900766b814ba5fd.pdf

[9] W. Natthapol, K. Teerakiat, "Microclimate real-time monitoring based on ZigBee sensor network", in Proc. of Sensors, Christchurch, New Zealand, 2010, pp. 1814-1818.

AUTHOR BIOGRAPHY

Emir Pecanin received his bachelor's degree of Informatics from the State University of Novi Pazar in 2009. In the period of 2010 to 2016 he worked at the State University of Novi Pazar as a teaching assistant on courses of the Departments of Computer Technologies and Mathematical sciences. During this period, he co-authored an electronic version of the script used in the course laboratory exercises. He was a member of the project financed by the Ministry of Education, Science and Technological development of Serbia. He is a PhD candidate on Faculty of Technical Sciences, University of Priština temporarily settled in Kosovska Mitrovica on the Department for Electro-technical and Computers Engineering. His research interests are data mining, cluster analysis, data warehousing and ETL processes, theory of information, coding theory, education, software development and WIFI systems. His earlier research included the proposition for the development plan for the interactive socio-educational e-learning platform and the implementation process of the ETL in databases. His main research focus is the development of streamlined methodologies for software and hardware implemented systems (digital coders, VoIP systems etc.) applicable in laboratory environment and the application of data-mining and EDM methods used for the evaluation, validation and prediction of the behavior of the mentioned systems. He an author of the article published in prestigious international journal and he is an author and co-author of the five conference articles of the national and international significance.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7, Issue 5, November 2017

Milos Ilic finished Master Academic Studies at Faculty of Electronic Engineering, University of Nis, Serbia. He graduated at the study program Computer and Informatics, module Information Technologies. He is currently a PhD student in the program of Electrical and Computer Engineering at the Faculty of Technical Sciences in Kosovska Mitrovica, University of Pristina, Serbia. The field of PhD thesis research is interdisciplinary application of Data mining technique and wireless telecommunications in Precision Agriculture. He works on the processing of large amounts of data (meteorological data and data about appearance of the disease), which are indicators of favorable conditions for fruit trees infection, by using data mining techniques. This can lead to a successful prediction of the corresponding moment for chemical protection. He is employed as a teaching assistant at the Collage of Agriculture and Food Technology in Prokuplje, Serbia. Milos Ilic areas of interest are Data Mining, Object Oriented Modeling, Artificial Intelligence, signal processing and data security. He is author of a number of papers in the field of data mining and wireless telecommunications. In addition to papers from these areas, he published significant papers from the field of data protection, electronic services and electronic government.

Prof. Petar Spalevic finished Faculty of Electrical Engineering at the University of Pristina, Serbia. He completed his postgraduate studies at the Faculty of Electronic Engineering in Niš, where in 1999 he defended his master's thesis entitled "Complex coherent optical telecommunication systems". In 2003 he defended his doctoral dissertation entitled "Performances of IM-DD optical systems in the presence of disturbances that occur along the nonlinear-dispersive optical fiber" at the Faculty of Electrical Engineering University of Niš, Serbia. He is author and co-author of number of scientific and professional papers published in international and domestic journals and international and domestic conferences. In 2015 he was elected as a full-time professor at the Faculty of Technical Sciences in Kosovska Mitrovica, University of Pristina. Beside Faculty of Technical Sciences he works as full-time professor at the Singidunum University too. He participates in a number of projects financed by the Ministry of Education, Science and Technological development of Serbia. His areas of interest are: Wireless Telecommunications, Optical Telecommunications, Statistical Communication Theory, Object Oriented Modeling, and Object Oriented Programming.

Prof. Mladen Veinovic finished his bachelor studies at School of Electrical Engineering in Belgrade, Serbia. In 1986 he graduated at the Electronics study program. 1990 at the same faculty he finished master academic studies. He graduated from the study program Automatic Control. In 1996 he defended his doctoral dissertation at the School of Electrical Engineering in Belgrade, Serbia at the study program for Theoretical Systems. He works as full-time professor at Faculty of Informatics and Computing at the Singidunum University. In the same time he is rector of Singidunum University. His areas of interest and research are: Computer Networks, Data security, Network security, Cyberspace, Databases, and Data Mining. He is author and co-author of number of scientific and professional papers published in international and domestic journals and international and domestic conferences. Beside journal and conference publications he is author of different teaching books from the field of computer networks. He participates in a number of projects financed by the Ministry of Education, Science and Technological development of Serbia.

Dr. Zoran Todorovic finished his bachelor studies at Faculty of Electrical Engineering stated in Pristina, Serbia. In 2001 he graduated at Electronics and telecommunications study program. In 2016 he defended his doctoral dissertation in the study program of Electrical Engineering and Computing at the Singidunum University. In the period from 1999 to 2006 he worked as teacher at Secondary Electro technical School “Miladin Popović” in Priština- Gračanica. In the period from 2006 to the 2014 he was the director of the same school. He is currently employed as a teaching assistant at Higher Technical Professional School Zvecan, Serbia. His areas of interest and research are: electrical engineering, communication, computer science, and distance learning. He is author and co-author of number of scientific and professional papers published in international and domestic journals and international and domestic conferences.