Tele-control of Remote Digital Irrigation System Performed through Internet

Akin Cellatoglu[1] and Balasubramanian Karuppanan[2]

[1] Dept. of Comp. Engg.,
[2] Dept. of EE Engg.,
European Univ. of Lefke,
Turkish Republic of Northern Cyprus,
Mersin-10, Turkey
{acellatoglu,kbala}@eul.edu.tr

Abstract. There are two aspects of this project concerning to remote sensing and control related to electronic plantation and irrigation system. First part is dealing with the remote sensing of desired parameters in an unknown location as to decide and establish possibly an appropriate electronic plantation unit. Here, the desired parameters are sensed through appropriate transducers and live data are uploaded into the website automatically. In a remote station, by accessing the website the parameters conveyed are gathered and saved in memory. After collecting the data for a considerable period of time an analysis is made to decide the suitability of the area for establishing a plantation unit. The second part of the project is running an already established irrigation system by monitoring the desired parameters in the remote station and issuing control signals to switch ON or OFF the selected appliances as to maintain the irrigation automatically and efficiently. The methodologies used are presented with an analysis.

Keywords: Telemetry, remote sensing, digital irrigation, tele-control, electronic plantation.

1 Introduction

Deciding to establish an appropriate plantation in an unknown remote area needs a long term investigation of the land in monitoring desirable parameters. An electronic method of area surveillance and monitoring would be helpful for such tasks. The essential parameters to be sensed for establishing an appropriate plantation unit would be water, wind, temperature and few others [1, 2]. Water is the main natural resource of irrigation system which keeps the plants to grow efficiently and without which no plantation unit could be established. The continuous availability of water throughout the period of plantation on cropping has to be ascertained.

2 Telemeter of Essential Parameters for Plantation

In the remote location identified for establishing the plantation unit the appropriate transducers for sensing the parameters are to be installed at chosen points distributed

N. Meghanathan et al. (Eds.): CCSIT 2012, Part II, LNICST 85, pp. 186–195, 2012.

in the identified area of plantation. Transducers installed at chosen locations provide the electrical signals for the parameters under test and the signals are conditioned as in conventional manner and conveyed to the remote end.

2.1 Parameters to Be Sensed

As water is the primary natural resource for the irrigation system the availability of water should be assessed first and confirmed. There can be natural water reservoirs which would collect water flowing as occasional or continuous water streams from rains or from opening of water beds. If there would be hills nearby and if they hold snow during winter they also supply water in summer to the reservoir due to melting. By physical inspection about the deepness of the reservoir and the capacity of the storage in long term the water level accumulated in the reservoir during different days of the year has to sensed and monitored. There are several water level sensors used in practice [3-5]. We use here the capacitive type of transducer where the capacitance changes due to change in dielectric constant resulted due to the level of the water. The capacitance is converted into frequency [6] and frequency is converted into voltage by a frequency discriminator.

During irrigation periods the moisture contents of the soil has to be sensed. Nevertheless, as to assess the natural moisture contents in the absence of plants also would provide information about the selection of plants for that location. Here again we use capacitive type of pickup to get a signal in voltage proportional to moisture content of the soil.

The ambient temperature experienced during different periods of the day, month and year also is an important factor to be monitored. This would help in deciding the type of plants for the plantation. We use Thermistor type of transducer included in Wheatstone bridge to get a voltage signal proportional to temperature. Appropriate linearization [7] is performed by hardware at the transducer level itself.

Natural wind flow within limits helps to make the growth of the plants. Heavy wind will have ill effect on the growth of certain type of plants. Therefore the velocity of wind flow is another desirable parameter needed to be sensed. Several types of wind flow sensors are used in practice such as ultrasonic type. As this type of sensor cannot align itself to the direction of wind we use miniature windmill [8] to sense the wind flow efficiently.

Ambient light available due to solar radiation helps the growth of most plants. This is another desirable parameter to be sensed. Photo sensor circuit is used to sense the ambient light.

Humidity of the environment influences the growth of most plants. Standard humidity sensor is employed to monitor the humidity [9]. Fire detectors may help in assessing how best the area is immune to catching fire with plantation of certain type of plants. Standard fire detectors [10] are used in this project and kept at selected locations evenly distributed in the field. The frequency of catching fire in summer and also in winter can be monitored.

For assessing the consistency of the fertility of the soil its pH value is monitored [11] throughout the year during different conditions of climate. As manual inspection of the site is only rarely done, the movements of forest animals over the area also are to be monitored. Although sensors could be arranged for sensing moving objects for such requirements, it is desirable to capture the video image of the site and transmitted to the remote location. Frozen still images transmitted would help in assessing several aspects of the site. Heavy fire, animals, hunters and group of birds or grasshoppers which would be bothering the crops are easily captured by video and visualized at the remote end.

If there is a water stream or water channel connecting the site to outside township or village, availability of water flow is sensed by installing flow sensors at selected points in the stream. If water is available throughout the year the crops cultivated could be transported to external places through boating service.

These are the desirable parameters to be sensed. If additional parameters are needed to be studied they can easily be included in the system for sensing and transmission. Appropriate reservations are made in hardware and software for insertion of the extended parameters in future.

2.2 System Design for Telemetry

The sensors are located at chosen locations of the area to be investigated. The signals from the transducers are conveyed to a computer installed in base station setup in the plantation site. The computer in turn arranges to upload the data to website. Once it is uploaded to website it can be monitored in a computer at any remote location and an analysis can be made. In the past, digital control of a model digital factory through web [12] was reported. The features of the project are suitably modified and adopted to the present application yielding enhancement in performance.

Fig.1 shows simplified schematic of the system monitoring remotely the parameters. In the base station of the plantation site one PC, lab top or notebook is needed to be fixed with wireless card attachment accessing the server and the internet. Since the transducers are located at different places, use of cables connecting to computer may not be feasible. Therefore, modular wireless communicating unit such as the popular USB data card is used for computer providing access to internet.

Each transducer has a mini wireless communicator through which the data are continuously transmitted to the base station. The data from all wireless transducers are collected in the receiver extended to PC and saved in memory as a table which is updating its contents continuously. The computer being extended to internet the table is updated periodically in the website. In the remote PC after giving the user name and password the website is open and the table can be visualized. For use in analysis package, the table is periodically transferred and saved in computer hard disc.

Fig.2 shows the simplified schematic of the wireless transducer data communication system. The transducer analogue signal is digitized with an ADC and transmitted as PCM-BPSK signal as to ensure higher probability of detection. All transducer signals are transmitted via the wireless communicating unit except the

transmission of video image got through web camera. Video image of web camera is saved in a notebook and directly uploaded to internet through wireless data card. If power supply is not available in the site of exploration then modular power supply unit [13] generating electric power from mini solar panel and mini-windmill are to be included in each transducer sensing and communicating the signal.

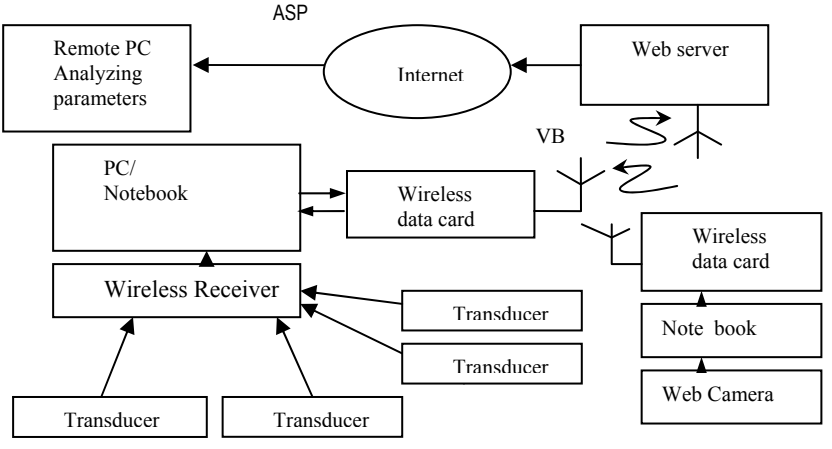

Fig. 1. Telemetering of Plantation Parameters

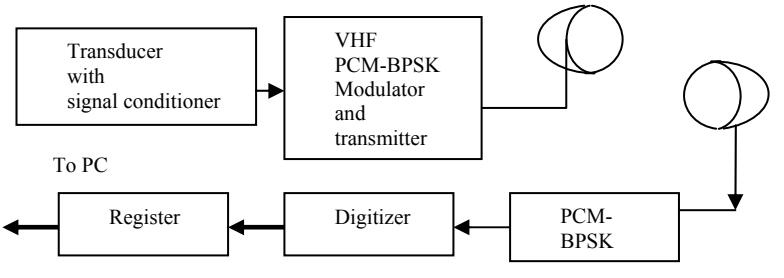

Fig. 2. Wireless Communication of the Transducer Signal

2.2.1 Software Medium and Link

The link to internet from webmail server is made through Visual Basic. As internet is accessible for the system manager as a client stationed at remote location he can view the table as provided by ASP. The server running the VB program gets the data sent from the PC and with the help of ASP put these data into webpage for accessible to remote PC.

2.2.2 Monitoring the Parameters in Remote PC

When the Plantation website is open in the remote manager PC it asks for user name and password as to bring the table of sensed parameters to the screen. Table 1 shows its form of appearance. The current data appearing in the table are saved in reserved memory locations as required for analysis package. There is a test column in which the results of self test made at the transducer end is provided. If it is not OK then corrective measures are to be taken at remote PC.

Table 1. Window Appearing in Website

Name of Sensor	*Present Data*	*Test*
Temperature	xxxx	OK
Water Level in lake	xxxx	OK
Water Level in Overhead Tank	xxxx	Error
Present Wind flow	xxxx	OK
Average Wind flow of the day	xxxx	OK
Moisture contets of soil	xxxx	OK
pH value	xxxx	OK
Humidity	xxxx	OK
Fire and smoke	xxxx	OK
Water flow in stream	xxxx	OK
Photo Sensor	xxxx	OK

2.3 An Alternate Design for Telemeter with Wireless Sensor Node

The wireless sensor node is a part of wireless sensor network. The node known as sink node attached with the computer with USB port collects information and transmits to other nodes. This node can be extended to satellite link with the use of appropriate interfaces. By linking the wireless sensor network to a satellite transmission, the data from triangulated radars for regional exploration has been reported recently [14]. This is now extended to the present application for transferring transducer parameters to remote monitoring PC.

The simplified block diagram of the wireless sensor node is shown in Fig.3. A microcontroller is the heart of this node. The microcontroller reads all sensors data and saves them in memory at reserved locations. Through appropriate USART (Universal Synchronous Asynchronous Receiver Transmitter) interface the data are transferred to the STX-2 [15] Satellite Transmission board. It radiates the signal at 2.4GHz. The satellite network receiver gets these data and puts them in the monitoring PC. Therefore the satellite receiver is to be installed in the premises of the PC monitoring the sensed parameters.

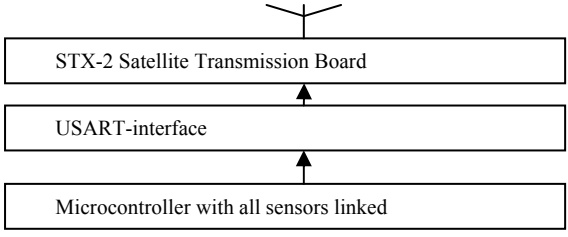

Fig. 3. Simplified Diagram of Satellite Based Sensor Node

2.3.1 Comparison of Wireless Sensor Network and Internet for Transmitting Transducer Data

The wireless sensor network is being used for different applications without access to satellite link. Each node can transmit and receive information as to satisfy the environmental requirements. The processing of information is done at the sink node linked to a computer. It has restricted radio range.

In this application as the remote monitoring PC is situated at a far place, the help of satellite link was necessitated in transferring the transducer parameters. The hardware involvement in using the internet communication and the satellite link are more or less the same. The cost involvement in using internet and satellite link has to be explored. The delay of information is not a critical issue in this application and therefore the performances of both mediums are well acceptable.

3 Digital Irrigation System

In the telemeter system described above the parameters sensed at one place are monitored in computer in a remote location and there is no control activity. The objective of that implementation was to get agricultural parameters for establishing an appropriate plantation system.

In this part we run and maintain automatically a remote irrigation system where the plantation already exists. We use partly the facilities available in the previous project and include remote control activities so as to fulfill the requirements. We observe in a computer the sensed parameters from the irrigation site transferred through internet. After making an analysis control commands are issued through internet to switch ON or OFF selected appliances in the irrigation system.

Regular routine works such as opening the valves periodically to keep watering the plants as per the programmed timings are done locally in the irrigation spot.

3.1 Parameters Sensed for Irrigation

As the main objective of irrigation is to maintain required moisture contents in the soil for entire duration of cropping the moisture sensing becomes essential parameter for this task. The desirable parameters to be sensed are as follows. *i*. moisture contents of the soil *ii*. temperature *iii.* wind flow *iv.* light *v.* water level in the reservoir lake *vi.* water level in the overhead tank. Provisions have been given for including additional parameters in the sensor table.

3.2 System Design

Fig.4 shows the simplified block diagram of the digital irrigation system through internet with duplex communication. The essential parameters sensed by transducers at various locations are transmitted to the computer at irrigation location and then uploaded in the website, all done similar to the previous environment evaluation project. The computer at the irrigation spot is interfaced to a PIC microcontroller which takes care of *i.* controlling the devices as per the command issued by remote PC through website and *ii*. Controlling the regular routine irrigation activities as per its program.

There are two water pumps included in the system. The deep well pump is used to pump the underground water from rigged well to the overhead tank supplying water to irrigation. Natural water reservoir like lake is another source supplying water to the overhead tank. In order for the irrigation to perform smoothly the water level in the overhead tank should be maintained at specified level. When this level drops and if the water level of the reservoir is good enough then that pump is preferred to be switched ON first. If it is not enough then the deep well pump of rigged well is operated to fill the overhead tank. Decisions are made to switch ON a particular pump depending upon the moisture contents, water levels, past history of the switching made on the pumps.

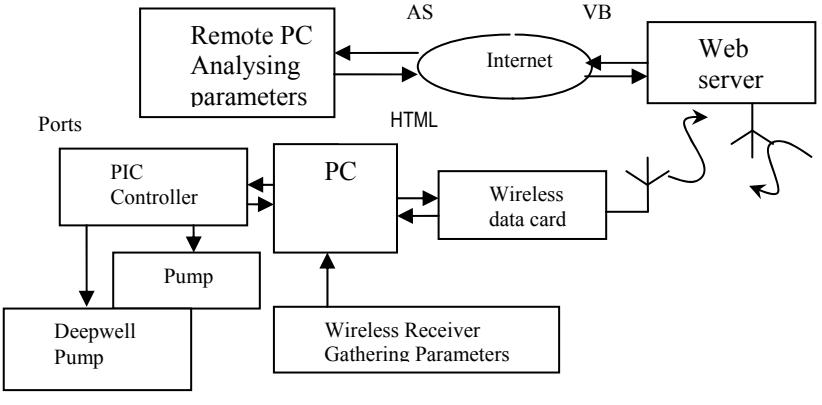

Fig. 4. Remote Control of Digital Irrigation System

When the website is open in the remote PC two windows can be seen in the screen. The first window is like a table shown in Table 1 informing the status of the transducer parameters included in the system. The second window is meant for control action and it appears as shown in Table 2. Only two pumps are included in the system for control and the table shows their present status. Also the present status of irrigation feed whether connected to overhead tank or cut OFF is also indicated . There is another column marked as control column which can be changed by the manager at the remote PC. For instance, in the table the present status of deep well is shown as OFF and the control also is shown as OFF. After making an analysis and decision if the deep well pump has to be switched ON the manager just types ‘ON’ in this field. This issues necessary command in the PIC at the site to switch ON the deep well pump.

Table 2. A Simple form of Control Table Window Appearing in Website

Control Devices	*Present Status*	*Control*
Deepwell pump	OFF	OFF
Overhead tank pump	OFF	ON
Irrigation feed	OFF	ON

The server running the VB program checks for any command issued from the remote manager PC. If a command exists then it formulates the appropriate bytes and sends them to the PC at the irrigation spot for issuing necessary control actions to PIC for switching on the pumps.

3.2.1 PIC Control

The PIC connects the water tap daily to the feed tubes going to all plants for a prefixed time as in the program. The time period is changed by the remote PC after making the analysis of moisture contents of the soil, temperature, water levels in the reservoir and the overhead tank and the ambient light. Therefore, in the PIC monitoring program it checks for the commands issued from the server in response to remote Manager PC. Therefore, while performing the regular daily routines it also actuates the commands issued from the remote PC. The main control actions arising from remote end are switching ON or OFF the two pumps and the irrigation feed tube.

4 Performance Analysis of the Systems

Both the systems described employ internet as the tool for communication. Security concerns, testability, maintainability, limitations and extendibility are the major factors to be analyzed as a means of assessing the performance of the systems.

4.1 Security Concerns

When the website in the remote Manager PC is open it asks for user name and password as to see the respective table as window. As it demands user name and password it ensures security. By making the password issue a complex concern the security aspects could be strengthened.

4.2 Testability

Semi automatic testing is performed by visiting the plantation site and checking the parameters with various sensors and the magnitudes of signals can be verified in the website. Test signals at different levels are inserted and watched in the website for their changes and also the time constant involved are tested. The time constant depends on the communication path between the source and the destination and the bit rate of transmission. The status of sensors and control appliances are checked with other available communication mediums as well. By these cross checks of the data reliability of the remote sensing system and tele-control schemes are ascertained.

4.3 Maintainability

Malfunctioning of any of the devices can provide wrong information about the parameters and the analysis package might produce an error. This is to be avoided by properly maintaining the devices in working conditions. Each transducer is backed up with a standby unit and a local simple testing process is carried periodically as to switch ON the standby unit as active transducer and test the output of both of them. If the outputs do not tally, the error signal is communicated along with the transducer signal to the website for taking corrective measures at the other end. The transducers employed are fool proof ones that it provides self generated error output bit, if any.

4.4 Limitations

The sporadic interruptions occcuring randomly in the internet such as disturbances in the server level or in the satellite communication medium influences the remote data acquisition system. Nevertheless, as the decison is not taken instantly such disturbances do not have any impact on the system performance.

4.5 Extendibility and Inclusion of Several Other Parameters

This system has no limitations in extending additional parameters and control appliances needed for different environment in digital plantation or digital irrigation system. When hardware appliances are brought under remote control it needs revision in the software when it exceeds the reserved number of parameters and control appliances. This is only a minor task and could easily be performed.

5 Discussions and Conclusion

Remote sensing to recover the information about establishing a digital plantation system helps acquiring the information without the manual observation and attention. This being an automatic system unavailing manpower and providing information for long period like a year it is highly preferred in several instants.

As internet usage has become a common means of sharing and exchanging information between users its usage for implementing remote control of a digital irrigation system simplifies its communication process without calling for special communication systems. On the other hand internet is still growing sector with more and more incorporation of additional strategies and overheads and this act would certainly enhance the features of internet based remote sensing and remote control systems.

In place of single channel wireless data transmitter used at each transducer for transmitting information to PC at the base station, one can think to use wireless sensor node and network. In this case it has the advantages of reliability ensured by the wireless sensor network. On the other hand this activity uses only a part of facilities available in the wireless sensor node and utility part is low.

Only three control actions are included in the system reported. It would be easily possible to extend further as many control actions as needed in another environment concerning this application or any other related applications.

References

1. Saygi, B., Yildirim, Y., Cabuko, C., Kara, H., Ramadan, S.S., Esemenl, T.: The effect of dehydration and irrigation on the healing of Achilles tendon: an experimental study. Turkish Journal of Trauma & Emergency Surgery 14(2), 103–109 (2008)
2. Melby, P.: Simplified Irrigation Design. John Wiley and Sons, NewYork (2010)
3. Rangan, S., Sarma, G.R., Mani, V.S.V.: Instrumentation Devices and Systems. Tata McGraw Hill, New Delhi (2003)
4. Balasubramanian, K.: Microprocessor based process control system. J. Instru. Soc. of India 17(2), 151–155 (1987)
5. Bera, S.C., Ray, J.K., Chattopadhyay, S.: A low-cost noncontact capacitance-type level transducer for a conducting liquid. IEEE Transactions on Instrumentation and Measurement 55(3), 778–786 (2006)
6. Balasubramanian, K., Cellatoglu, A.: Precision Pneumatic Pressure Measurement with diaphragm based mechatronic devices. International Journal of Electronics - Taylor and Francis 97(1), 45–62 (2010)
7. Balasubramanian, K.: Improved techniques of transducer linearization. In: Proceedings of the IV National Congress of Electrical Engineers, Izmir, pp. 757–760 (September 1991)
8. Balasubramanian, K., Cellatoglu, A.: Improvements in Home Automation Strategies for Designing Apparatus for Efficient Smart Home. IEEE Trans. on Cons. Electronics 54(4), 1681–1687 (2008)
9. Kim, H., Hong, S.-M., Lee, J.-S., Moon, B.-M., Kim, K.: High sensitivity capacitive humidity sensor with a novel polyimide design fabricated by MEMS technology. In: Proceedings of 4th IEEE Conference on Nano/Micro Engineered and Molecular Systems, pp. 703–706 (2009)
10. Balasubramanian, K., Cellatoglu, A.: Analysis of Remote Control Techniques Employed in Home Automation and Security Systems. IEEE Trans. on Cons. Electronics 55(3), 1401–1407 (2009)
11. Matsuo, J., Hizawa, T., Sawada, K., Takao, H., Ishida, M.: Charge Transfer Type pH Sensor with Super High Sensitivity. In: Proceedings of Solid-State Sensors, Actuators and Microsystems Conference, pp. 1881–1884 (2007)
12. Balasubramanian, K., Cellatoglu, A., Akdemir, T.: Remote Control of Digital Factory through Web. In: Proceedings of the 41st IEEE Southeastern Symposium on System Theory (SSST 2009), Tullahoma, TN, pp. 368–372 (March 2009)
13. Cellatoglu, A., Balasubramanian, K.: Renewable Energy Resources for Residential Applications in Coastal Areas: A Modular Approach. In: Proceedings of the 42nd IEEE South Eastern Symposium on System Theory (SSST 2010), Texas, pp. 340–345 (March 2010)
14. Cellatoglu, A., Sari, M., Rahnama, B., Balasubramanian, K.: Remote Sensing of a Geographical Environment with Portable Radars and Satellite Link. In: Proceedings of ARTCom 2011 Innternational Conference, Bangalore, pp. 128–132 (September 2011)
15. Axonn Corporation, Satellite Transmitter Product STX2, New Orleans (2005)