Urban Rooftop Farm Monitoring System (URFMS) using WSN

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ABSTRACT

Urban rooftop farming has gained importance due to rise in concrete jungle at faster phase, thereby leaving smaller room for urban citizens to cultivate/grow their interest and requirements. The day to day demand in green vegetables and love towards their indoor and outdoor plants can be achieved through urban rooftop farming. This demands lot of care and precise monitoring systems for their healthy vegetation. A wireless sensor network model for precise monitoring of urban rooftop farming was proposed. This model include monitoring the environmental factors that effect the health of the plantation like light, temperature, humidity and water content in the soil. The monitoring system will indicate the necessary actions to be taken up so that the plantation remains healthy. A typical example can be the moisture level in the soil going below the threshold value will trigger the water sprinklers. The real time implementation of the proposed monitoring system is also carried out by generating a testbed to perform the preliminary studies and results have been discussed in the paper. A simulation model has been generated in this regard to carry out further studies on energy efficiency, low latency and better monitoring, the results are discussed.

Keywords: Rooftop, farming, environmental factors, real time, monitoring system, WSN

1. INTRODUCTION

The rapid urbanization lead to the fast development of urban cities. But, these cities are fast becoming concrete jungles leading to rapid depletion in greenery thereby causing many environmental problems and leaving no room for garden enthusiasts. Rooftop Urban Farming (RUF) is a viable solution to this problem. RUF is often described as the practice for food cultivation on the building rooftops. RUF not only adds to the aesthetic sense of the building but also provides food along with other benefits such as temperature control, pet life environment, architectural enhancement, oxygen filled air and recreational opportunities. Implementation of RUF helps in supplementing the food production as well as bringing down the hazardous levels of pollution existing in urban environment.

For precise maintenance of RUF as well as providing nourishing environment for the plants, Wireless Sensor Networks (WSN) can be employed. WSN can be basically used in the farming environment to sense different parameters like light, temperature, moisture content and humidity which are essential for healthy plant growth. Basically, WSN is considered as collection of sensor nodes working collaboratively with each other for sensing, computing and communicating. In the present application, WSN can be integrated with actuators like fans, sprinklers and light bulbs. WSN effectively reduces the human effort in maintaining the plants. If a particular parameter is not optimum for the growth of the plant then these sensors send signals to the source node and then a signal is sent to the actuators. The actuators provide artificial means to cope up with the unfavorable conditions for the plant growth. WSN farm monitoring system performs the following functions:

1. To sense environmental parameters
2. To identify the sensing location and data aggregation
3. To transfer the aggregated data from the source to sink node for better decision making
4. To trigger the necessary actuator

The system deployed for this purpose does not need to monitor the parameters continuously. The data can be monitored on demand basis depending on the parameter significance and the application. In this work, a real time implementation of WSN for sensing the environmental conditions like light, temperature etc.. is performed. We also provide a WSN monitoring model that can be implemented in RUF using Network Simulator.

The paper is organized as follows : section II gives the related work, section III provides the hardware implementation model, section IV shows the simulation work and section V concludes the work.

2. RELATED WORK

Many works are proposed for monitoring of environmental parameters using WSN. The works [1], and [2] gives the real time monitoring of parameters essential for agriculture using WSN. In fact in some cities like Dhaka, Bangladesh rooftop farming is used a strategy for food security [3]. This strategy ensured that they became self sufficient in food production despite the rapid unplanned urbanization. The work [4] suggest that implementation of urban farming in high density urban cities would achieve environmental, social and economic sustainability of the entire community. The work [5] establishes a framework for a W SN based real-time monitoring system to understand the levels carbon monoxide in street-level spatial-temporal changes of carbon. The work [6] uses WSN for predicting the crop development on the basis of site conditions. The work [7] uses WSN for monitoring the odor and levels of hazardous gases in a 'swiftlet' houses which are nothing but artificial birds habitat.

3. HARDWARE IMPLEMENTATION

3.1 Zigbee radio

Xbee S1 radio module shown in fig 1 using Zigbee protocol for communication is used for communication purpose

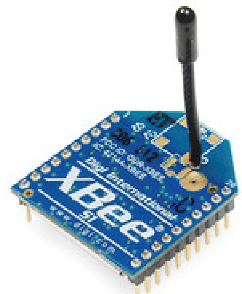

Figure 1. Xbee Radio Module

3.2 Light Sensor

Directional light sensor NR–S–DLS–001 shown in fig 3 developed by Nex-Robotics of IIT Bombay which is basically a photo transistor with precision lens assembly is used

Figure 2. Light Sensor

3.3 Temperature Sensor

The temperature sensor LM 35 shown in fig 3 developed by NEX-Robotics is used for sensing temperature. LM 35 is the sensor whose output voltage is linearly proportional to the temperature in degree celsius.

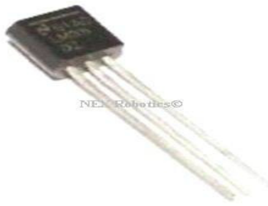

Figure 3. Temperature *Sensor*

3.4 Soil Moisture sensor

The soil moisture sensor probe V H400 shown in fig 4 developed by Vegetronix is used which enables the moisture content monitoring at a relatively lower cost.

Figure 4. Soil Moisture Sensor

3.5 Development board

We used ATMEGA640 development board for integrating the sensors and radio modules. Some of the features of ATMEGA640 that are necessary for our present application are

1. Throughput of 16 MIPS at 16 MHz
2. Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
3. Four 16-bit Timer/Counter with Separate Prescaler, Compare- and Capture Mode
4. 16-channel, 10-bit ADC
5. Two/Four Programmable Serial USART
6. Master/Slave SPI Serial Interface
7. Byte Oriented 2-wire Serial Interface
8. Programmable Watchdog Timer with Separate On-chip Oscillator
9. On-chip Analog Comparator
10. Interrupt and Wake-up on Pin Change

3.6 Experimental Testbed

The experimental setup deployed in the urban farm is shown in fig 5. We used two sensors for light and temperature sensing respectively. The ATMEGA640 development board is used to digitize the analog output of the sensors and to display it on the LCD screen as well as forward the data the XBee module connected. The XBee module transmits thedigitized sensor output.

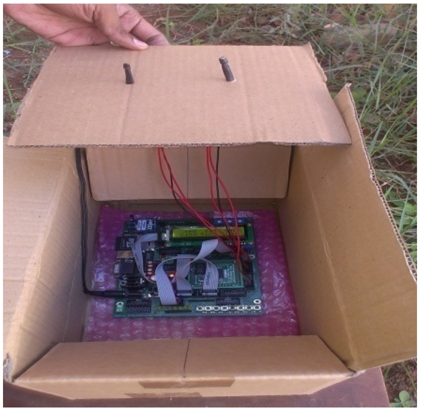

Figure 5. Experimental Test bed

3.7 Monitoring Station

The monitoring station for logging the temperature and light information is shown in fig 5 . The XBee module receives the data and the data is logged onto the PC using RealTerm via USB software platform.

Figure 6. Test bed for logging the information

4. SIMULATION MODEL

A green house simulation model is implemented in Network Simulation as shown in which has 6 sensors mounted to sense three different parameters like light, temperature and humidity. All sensors communicate the information to the sink node which controls the actuators like bulbs, fans and sprinklers.

Sensor nodes adopted in the simulation are binary sensors which emits only binary output +1 or -1. The sensor outputs high whenever there is a change in the threshold value which is given in the below example. Let us take typical light intensity values in the course of day, the light intensity increases with time, reaches a peak value at about afternoon and again starts decreasing. Let us take 7 typical values of light intensity in the course of day 10, 20, 35, 50, 30, 15 and 5 and the threshold is set to be 25 below which the light source should be ON. Now as the initial value is less than threshold, the sensor outputs a high +1 and the sink node initiates the light source actuator. In the next case, as the light intensity 20 is still than 25, the sensor does not transmits any output and in the case, since 35 > 25(threshold) the node again transmits a high +1 triggering the sink node to shut down the light source. This approach results in high energy efficiency. Using multiple sensors for monitoring is also employed.

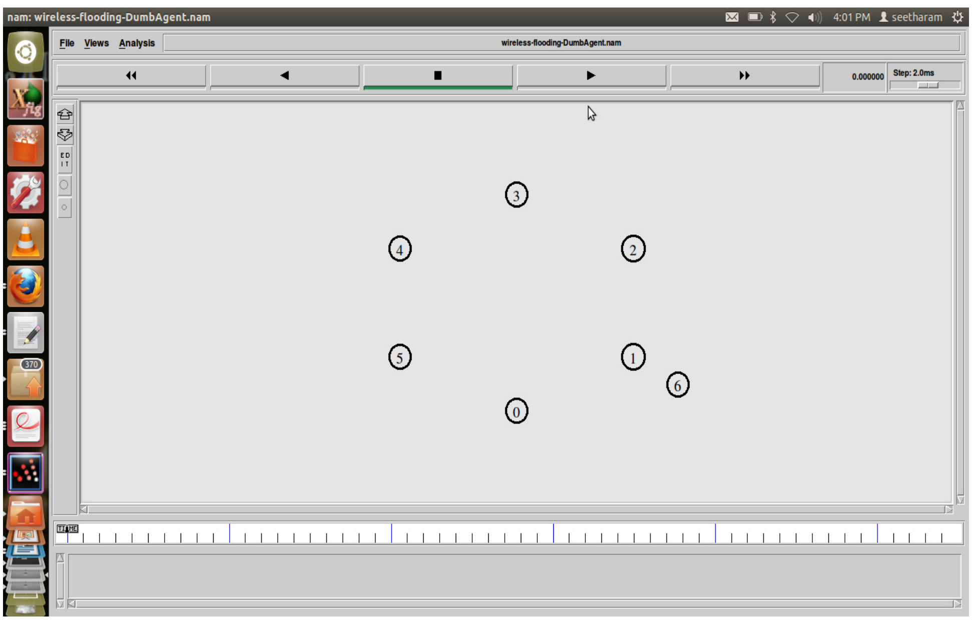

Figure 7 : Simulation model

Data Coding technique is used here for data fusion. The test values used for temperature, light intensity and humidity for simulating the monitoring system is shown in fig 5. The thresholds are set as 10, 3.7 and 1.35 for light, humidity and temperature monitoring respectively. So, whenever the test values of the respective parameters crosses these values, then the sensors need to transmit a binary pulse to controlling station. Now, the controlling station based on the present state will send a control signal to the respective actuators. For example, if the light intensity increases from 9 to 11 (i.e., it crosses the light intensity threshold value 10) the light sensors communicates a binary pulse to the controlling station. The present state of the light actuator is ON and since it receives a binary pulse from light sensor, it changes the state from ON to OFF and thus sends the control signals to the light actuators.

We use the concept of information coding here to decrease the energy consumed for communication purpose. Data from the nodes of same type is collected onto one of the nodes and data is aggregated, then the aggregated data is sent to the sink node for making the decision. In our simulation model, the sink node controls the actuators.

5. CONCLUSIONS

In our work, we have implemented a hardware setup for monitoring environmental parameters using wireless sensor networks. We have used Zigbee radios for communication purpose. We also proposed a complete model for urban farm monitoring and the model is also simulated in NS2. We implemented the model using less communication overhead thus increasing the lifetime of the network employed for monitoring. The future can be extending the simulated model into real time implementation as well as developing a novel data integration mechanism

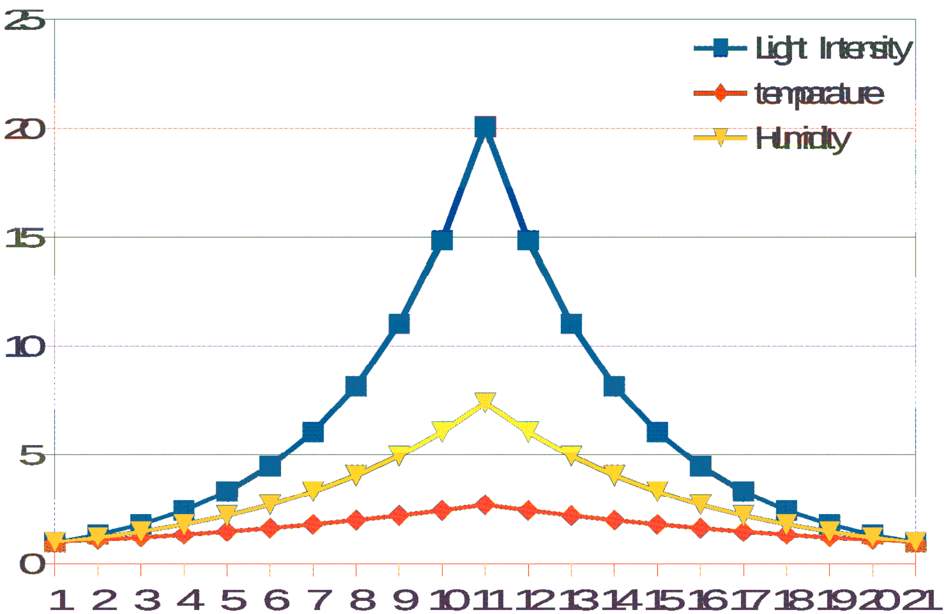

Figure 8 : Sensed Parameter Values

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