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An Evaluation of Greenhouse Parameters Using Embedded Sensor Networks

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Abstract

A greenhouse is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather.Many commercial glass greenhouses or hothouses are high tech production facilities for vegetables or flowers. The glass greenhouses are filled with equipment including screening installations, heating, cooling, lighting, and may be controlled by a computer to optimize conditions for plant growth. Different techniques are then used to evaluate optimality-degrees and comfort-levels of greenhouse micro-climate (i.e., air temperature, relative humidity and vapor pressure deficit) in order to reduce production risk prior to cultivation of a specific crop. With major technology developments for water sterilization and water recycling we are able to help commercial greenhouse growers to achieve considerable savings on water and fertilizer costs and at same time meet environmental regulations. Climate Control Systems is sought after internationally for greenhouse automation technology. We have dedicated ourselves to deliver the latest green technology that saves growers time and money and at the same time conserves the environments that surround us. In the past, most environmental control systems of orchid greenhouses in Taiwan used PLCs (Programmable Logic Controller) with poor scalability and control, and could not be connected to the Internet for monitoring from the cloud. For advanced database analysis and networking capability, the PC platform must be adopted. Therefore, PAC Systems (Programmable Automation Controller) with both PLC programming capabilities and PC functions is a better choice. The environmental control of the Orchid greenhouse switches on and off devices like fan, shade net, cooling/heat pump, liquid flow control, water-cooling wall etc. It is controlled by a control panel of electric controllers, and is driven by a motor, to adjust the greenhouse temperature, humidity, and other environmental conditions to the set parameters. One appealing WSN application is in environmental monitoring and greenhouses, where the plant conditions such as climate and soil does not depend on natural agents. To manageand monitor the environmental factors, sensors and actuators are critical. Under these circumstances, WSNshould be used to make a distributed assessment, spreading sensors all over the greenhouseby means of distributed clustering. This paper reveals some grave issues when a wireless sensor network is exposed to real world environment to monitor and manage greenhouse parameters.

Keywords

Wireless sensor network (WSN), greenhouse, environment control, CO2monitoring, distributed clustering.

I. Introduction

In the Precision Agriculture (PA) various techniques are available to monitor and control the required environmental parameters for the particular crop. It is particularly crucial to analyze the methods which can effectively manage the proper environment. The use of wireless sensor network for the large area is now becoming popular in green house technology of precision agriculture. The parameters of greenhouse to be control are increasing day by day so that it may cause the data traffic and congestion in the future. So that, the wireless sensors derived from PSoC technology with high-bandwidth spectrum or cognitive radio technology may be the proper solution for smooth data traffic and remote control of greenhouse from long distance.

With the use of greenhouse concept, the farmer can produce different crops in different climates and various seasons. In proposed design of the green house, the farmer can easily keep the desired Crop's environment conditions. WSNs consist of hundreds of even thousands of sensor nodes which may be sparsely distributed in remote locations. Thus, it becomes infeasible to recharge or replace the dead batteries of the nodes. As soon as, some of the sensor nodes in a WSN run out of energy, they stop functioning causing progressive deconstruction of the network. Therefore, one of the most stringent limitations that the development of a WSN faces is that of power consumption [1]. Due to current technological advances, the development of materials for tiny and low cost sensors became technicallyand economically reasonable.Inorder to put into practice a WSN, few parameters are to be well thought-out: deployment of wireless sensor nodes, uncovering of percentageof pollution (De Boer,M. 1998) and other environmental conditions, converting them into an equivalent electrical signals for processing.An enormous number of these sensors nodes can benetworked in countless applications (Van Egmond,N.D. 1998) that entail unattendedoperations fashiona wireless sensor network. Wirelesssensors are devices that vary in size from a portion of glitter toa floor of cards. Integration of a variety of components with an internal distributed clustering mechanism for these sensor nodes craft an exceptionalmonitoring system. A sensor node is functionally composed of:sensing unit that is intended and programmed to sense pollutants in air, light, temperature,humidity, pressure, etc., aconverter that converts the sensed signal from analog to digital signal, a processing unit process the signalssensed form sensor with aid of embedded

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memory, operating system and few related transceiver circuits. A radio unit facilitates communication from the node level to the sink level. Powering these components is classically one or two tinysized batteries.

There are also wireless sensors exploited inapplications that use a fixed assessment, wired power source and donot use batteries as power source.In an exterior environment where the power source isbatteries, wireless sensors are positioned in an area of interest thatis to be monitored, any in a random or known fashion. Thesensors self-organize themselves into a network using any clustering mechanisms, thereby proficiently grouping the sensor nodes to supervise the area for gas measurement, moisture levelsin airand transmit the data to a central nodecalled as cluster head (CH), which in turn periodically onward the aggregated data to the tenuously located base station (BS). The nodes may be the identical asthe other detection nodes or because of its augmentedrequirements or may be a more sophisticated sensor node withbigger power can be used. The most pro of wireless sensors isthat they may be implemented in an environment for extendedtime period, incessantly detecting the environment without the need for human interaction or action. If a centralized clustering method is used, the operation becomes immobile with unchangingdesign, leading to reduced scalability [2-11]. When a distributed clustering technique is employed, the CH can be rotated periodically, thereby thelife span of the wireless sensor nodes can be prolonged with added scalability (Boselin S.R., et al.,). This investigationdiscussesa quantity ofchief issues when a distributed clustering mechanism is used for real world environmental monitoring application.

II. Related Works

Many researchers observed that, the greenhouse technology is well accepted in agriculture engineering. The integration of wireless sensor network in green house is the recent concept which leads to precision agriculture. Blackmore et al. in 1994 [2], explained that, the system can be designed to increase the quality agricultural yield by, properly monitoring soil and environment. They also observed that, in early stage of WSN, farmers were reluctant to deploy it, because of high cost. Technological development has reduced the cost. In addition to MEMS technology for hardware, some other technologies like, satellite sensing, Remote Sensing, Global Positioning System and Geographical Information System are also contributing in overall progress [3]. Beckwith et al. had worked on WSN in large scale vineyard on very large scale design and deployment [4]. They work on 65 motes, which have only eight hops, to collect the data of pH values. Predesigned crop management in precision agriculture is studied in the Lofar Agro project, in Europe. In this project, Proper application of pesticides and fertiliser as per real time environmental changes is explored. For effective control of crop diseases like phytophthora, the information collected from a weather station and the wireless network is very much useful [5].

There are complementary types of technologies such as a GPSsystem, which can be added to perk up their performance. There is an imperative system for forest fire detection based on satellite imagery, which studies the images taken from satellites. But, weather conditions are greater important problem in thesesystems. Clouds and rain soak up parts of the frequency spectrum and lessens spectral resolution ofsatellite imagery. So, the performance of this arrangement changes very much. Satellites can keep an eye on a largearea, but the resolution of satellite images arenear to the ground [12-21]. A fire is detected when it has grown-up quite a lot, soreal time detection cannot be provided. Moreover, these systems are very costly.The system presents numerous advantages: automatic action,consistent data superiority, cost-effective use and rapid response but not in real-time. A novel system called Firesensorsock, to defend everysensor node of a wireless sensor network in order to keep away from these devices being damaged ordestroyed when they are sending the data, detecting or controlling a fire has been anticipated. Firesensorsock is an extraordinaryprotection dedicated to the thermal insulation of sensors that leave undamaged their ability to sensethermal data. Thus, the purpose of this work is to have a wireless sensor network that is intelligent to resistbeing burnt. The sensors will keep on transmitting data flow to the final user.

Besides, a WSN protected with Firesensorsock is capableof sensing thermal information in the open air. They are able to spot a fire and track the fire spread during itsspatial and temporal evolution.Nowadays, wireless sensor networks are widely used to watch, detect a fire and there is afair quantity of literature on it. An example is the FireBug system. A systembased on a wireless sensor network for forest fire monitoring has been plannedwith MICAmotes using GPS attached to it. Its purpose is to assemble environment parameters like temperature, relativehumidity and the barometric pressure whilst there is an active fire. Motes correspond with base stationand informationisamassed in a database server. Thus to have admittance to this server, a net browser based on a websignificance which is ableto communicate with the database server is required.This designuses the Crossbowsensor mote and the TinyOS programmed in the nesC language. Thissoftware is solely built up for embedded devices.The provisionsthat have to be well thought-out for such sort of network, together withliability of firefighters, smart scheduling and resource allotment, web services and incorporation.To fulfill these requirements,

FireNet has been projected. It is a wireless sensor networkstructural design where sensors are sprinkled in vehicles, figuring a self-organized heterogeneousnetwork with the fire fighters.FireNet design is considered tobe tremendouslysupportivefor fire rescue process.The Forest Fires Surveillance System (FFSS) was developed after that. If a fire is noticed, FFSSautomatically turns on an alarm to assist a hasty extinguishing of the spreading fire. In this piece of work, the nodesemploy TinyOS as the operating system. In adding up, the WSN exercise a minimum cost path forwarding (MCF) tohurl their information to the sink node.One morecharacteristics analyzed is the quantity of measurements taken from variedsensors to reduce error estimation.

A distributed algorithm is in useto resolve thissort of problem. The purpose of FireWxNet is to decide the behavior of fire rather than its detection. Itcontains a WSN that functions asa gauge to monitor weather conditions around an active fire. Webcams areemployedto acquire visual data of burned area and the base station which is capable of providing lengthy distancecommunication. For eachpredeterminedtime period, the arrangement measures environmental temperature, relative humidity, wind speedand itsdirection. In contrast, cameras present images constantlyregarding the current state of the vigorousfire. The arrangement uses lengthy distance wireless communication links, sensor networks and few web-cameras. The outcome of the arrangement is found to be exceptionallyfirst-class and they reveal that it isexceedinglysupportive to investigatethe fire behavior. Military applicationsare incrediblyand intimately related to the perception of the sensor networks (Rajaravivarma,V., et al.,). In reality, it is exceptionallyrigid to speak for definite whether motes were developed because of military and defense needs or whether they were invented autonomously and were subsequently useful to armed forces.

Concerningarmed applications, the province of concentration extents from information collection, normallyto opponent tracking (Hao,J., et al.,) or battleground surveillance. For instance, mines might be regarded as dangerous and obsolete in the future and may be replaced by thousands of separated motes that will sense an intrusion of defensive units. Outdoor monitoring is another celestial area for applications of wireless sensors networks. one of the fabulous examples is the exploitation of wireless sensor nodes on an Island. This wireless sensor network wasused for habitat observation (Dardari,D., et al.,). The sensor nodes that were employed were talented to sense and monitor the temperature, barometric pressure and humidity. Additionally, passive infrared sensors and photo resistors were engaged at a moderate level. The traditional arrangement was employed to effectively monitor the natural background of a bird and its behavior according to the changes in relative climatic conditions. For such reason, a quantity ofwireless sensor motes were installed inside birds burrows to speck out the bird's presence while the rest were set out in the close by location areas.

The data sensed by various motes are aggregated by the utilization of sensor nodes and are conceded to the monitoring station through the gateway.Management of precious assets like utensils, equipments anddiverse types of products can be a quandary (Boselin S.R., et al.,). Owing to this reason, the dilemma is highly distributed, as these corporationsexpand to the edge of the globe. One emerging gifted way to realize the tracking of asset and deal with this problem is believed to be with the use of wireless sensor networks. The appliance of sensor nodes in petroleum bunks and chemical warehouses refers to warehouses and storage management of containers or barrels.

The design is that sensor motes attached to large barrels will be intelligent to locate nearby locatedobjects, detecting their content inside and alerting wheninaptnesshappens with their own and aging effects.Health care system can also yieldfrom the use of wireless sensor nodes with the patients. Emerging applications in this category include tele monitoring human physiological statistics, monitoring of the patients within a hospital, monitoring drug administrator in hospitals, etc. (Lee, D.S., et al.,). In case of smart sensors, retina prosthesis chip constituting of hundreds of sensors are set within the human eye. This allows the patients with inadequate vision to see at a relative ample level. Cognitive disorders which mightprobably lead to Alzheimer's can be monitored and very well controlled at their premature stages with the aid of wireless sensors. Robotic applications previously implemented are the unearthing of level sets of scalar fields using mobile sensor networks and imitation of the task of bacteria for seeking and discovering dissipative gradient sources.

The tracking of a light source is complete with some of the basic algorithms. In addition, a reply to the coverage problem by robots and motes is accomplished for thick measurements over a broad area. The association of both static and mobile networks is accomplished with the aid of mobile robots, which travel around the environment and arrange motes that act as beacons. The beacons help the robots to portray the directions. The mobile robots can act upon as gateways into wireless sensor networks. Examples of such tasks are: supporting the energy resources of the wireless sensor network indefinitely, configuring the hardware, detecting sensor collapse and apt deployment for connectivity in the midst of nodes.Landslide discovery employs distributed sensor scheme for predicting theoccurrence of the landslides in hilly areas. The idea of predicting the hilly-area landslides by means of wireless sensor networks arose out of a must to alleviate the destruction caused by landslides to individual lives and to the railway networks.

A fusion of practices from terrain sciences, signal processing, distributed systems and fault tolerance is employed. A solitary peculiarity of these type of systems is that it joinsa quantity of distributed systems techniques and technologies to pact with the complexities of a distributed wireless sensor network environment where connectivity is underprivileged and power budgets are extremelyunnatural, while rewarding real world necessities of safety and fortification. Normally these methods make use of a collection of single-axis strain gauges united to contemptible nodes each one with unique processor, battery and exclusive wireless transceiver block.Forest fires, also recognized as wild fires are wild fires happening in wild areas and cause chief damage to human resources (Cerpa, A., et al.,).

These forest fires washes out forestsand mightconsequence in soaring human demise toll nearer to urban regions. Some regular causes of forest fires compriseof lightning, human carelessness and seepage of fuel to great heat. It is acknowledged that in a miniature number of cases fires are components of the forest ecosystem and they are remarkable to the life cycle of local habitats (Edoardo Biagioni., et al.).ensor-Clouds can be used for fitness monitoring by using a quantity of simply obtainable and most frequently wearable sensors like accelerometer and temperature sensors, so forth to fetch together patient's health-related information for tracking sleep action pattern,human body temperature and other respiratory situations.

III. Greenhouse Issues

The Greenhouse Environment: A recent greenhouse can consist of several parts which include their own local climate settings (Zhang Qian., et al.). Hence, quite a group of measurement points are also enviable. This smart environment isnecessarily demanding both for the wireless sensor node electronics and for theshort-rangewireless network in whichcommunication range is to a vast extent longer in wide areas [22-27].

Sensors: Speedy response time, relativehumidity and temperature, the sensor forms anideal solution forgreenhouse environment. Smart communication between the sensors is analogous to IIC interface. Patchy outputsignal is properly handled bya filterto obtainaccurate luminosityvalues.CO_2 measurement and processing takes quite longer time than othermeasurements and these sensor voltage supply must be withina fewer voltage levels. The CO_2estimation can beexamined from thecorresponding output voltage levels. The operational amplifier raises thevoltage level or generally increases the amplitude of the frail signal from the wireless sensor.

Greenhouses: A greenhouse is an array covering the ground frequently used for expansion and development of plants thatwill revisit the owner's assets (Jong-Won Kwon., et al.,). This arrangement is basically mounted with the belief ofdefendingthe crop and allowing animproved environment for its progress. This guard is much adequate toguarantee a superior quality in the production in some cases. But, when the foremost intention is to achieve animproved control on the horticulture expansion, it is indispensable to manage the variables thatsway the growth of a culture.The function of a greenhouse is generally to supply a more auspicious environment than the outside environment. Contrastingto what happens in the traditional agriculture, where crop yield depends on natural worldresources such as climate and soil, whereasa greenhouse shouldpromisebetter production independently ofclimatic factors.It is very important to examine that even a greenhouse protects crop from exterior factors, it may reasonsto several problems such as fungus and extreme humidity conditions. As a result, the mechanisms to detect and control a greenhouse atmosphere are awfullysignificantfor attaining improved productivity. To achievefirst-rate productivity, a superior control method isimportant and thusthe production costs also gets abridged.The central elements involved in a greenhouse control system are temperature, humidity, concentration of carbon dioxide, light radiation, water availability and minerals.

Temperature: Temperature is one of the most significant factors to be monitored because it isunswervingly related to the plant growth. Intended for all plants, there is a minimum temperature assortment considered to be perfect and to most plants this range is comparativelyvarying around 30ºC. Amongstthese temperature parameters of to be controlled are essentialthe extreme, maximum, minimum temperature and tolerably the difference between these temperatures.

Water and humidity: An additionalimperativeaspect in greenhouses is water. The assimilation of waterby plants is associated with radiation. The nonappearance or low level of water influences growth andphotosynthesis. Besides this, air and ground humidity also adjust the development of plants. The airhumidity is correlated with transpiration, while the ground humidity is interrelated to water absorption andphotosynthesis. An environment with extreme humidity decreases plants transpiration thereby reducingthe growth and may endorse the proliferation of fungus. On the other hand, low humidity levelenvironments might cause dehydration of the plants.

Radiation: Radiation is an influential element in greenhouse production and sunlight is the most importantsource of radiation. It is an indispensableconstituent to photosynthesis and for carbon fixing. The important radiation features are concentration and duration. The radiationintensity is allied to plant growth and the duration is unswervingly connected to its metabolism.

CO_2 concentration: CO_2 is important because it is an indispensable nutrient for plant development,allowing the assimilation of carbon. The carbon retaining process occurs throughout the photosynthesis,when plants take away CO_2 from the environment. Throughout the photosynthesis, the plant uses carbonand radiation to create carbohydrate, whose role is to permit the plant growth[30-31]. Therefore, an enriched air environment should add to the plant growth, but it isimportant to note that an unwarranted carbon level may turn the environment poisonous.

Sensor node functionality: Design ofsensor node consist of four fundamental functionalitiesa) Signal conditioning: The time gap between quantity of gasconcentration deposited on the sensing plates and the time required to clear the gas concentration on the sensingplates. b) Sense the changes in air: Sensors are used to sense the changesin gas concentration of different pollutants such as carbonmonoxide, carbon dioxide and sulphur concentration in air. Asthe output of the sensors are analog, the signal strength andcorrectnessneed to assured.c) Signal amplification: The signal detected by the sensors are in need to beamplified and regenerated to boost the accuracy of thesystems.d) Signal calibration: ADC provides the mapping between analog inputsignals to digital signals for processing.The integrated ADC in the microcontroller unit is used to renovatethe analog signal to the corresponding digital values[28-29].

Radio design and number of devices needed: In order to plan the wireless sensor network, the signal loss during its path in arural or forest environment has to be considered to the highest degree. The major parameter to be considered here is the coverage. How far the Wireless IP camera and the wireless sensorcould be from the access point to accept enough signal power has to be cautiously analyzed before real world implementation.

Hardware deployment: A router can be used as thecore controller. It is an embedded system that has a wireless IEEE 802.11 b interface, aFastEthernet interface in its board and so it meets the requisites. In addition, a router offers internally general purpose input/output (GPIO), UART (JP2) and ETAJ (JP1) ports. A fewextensions can be made to the router by using these ports.

Wireless IP camera: The wireless cameras chosen transmit MPEG-4 standard video compression, which has superiorcompression and excellence compared to other standards. It also consumes little bandwidth. MPEG-4 isfrequently used in video streaming over IP environments. The video is streamed by means of the HTTPprotocolwith very good quality results.Chosen cameras must betalented to transmit in both directions.

Photovoltaic system: The photovoltaic system is fashioned by a photovoltaic panel, battery, load regulator and aninverter. There are several basic types of photovoltaic panels, all of them employ silicon: monocrystalline cells,polycrystalline cells and amorphous cells. Polycrystalline cells are preferably used because they havesuperior performance than the amorphous cells and they are cheaper than themonocrystalline cells. There are various types of batteries that can be used in a photovoltaic system like VRLA battery and AGM battery.

System design and operation mode: The wireless sensors is usually placed invarious critical points with supplementary risk. Both the sensors and cameras are beneaththe coverage area of the access points.The mode of operation is as follows. All cameras are recorded with the corresponding coordinates wherethey have to budge and focus for each sensor placed in their visual coverage[32-33]. The server has a databasewith the location of the sensors and the name of the cameras placed in the rural area close to everysensor. When a sensor detects a fire, it sends analarm unswervingly to the server. This alarm message generally has the name of the wireless sensor. Whenever the server getsthis message, it searches in its database the neighboring wireless cameras to that sensor and sends them amessage with the name of the sensor that has sent the alarm and the location they must move to inorder to look at the image of that zone. Finally, the cameras shift their objective to the coordinates ofthe sensor and the fire fighter can corroborate ifthere is a fire occurrence or not.

User interface: A web page that shows the video streams received from numerous wireless cameras in real time has to be developed. Images are revealed without jumps and there is no any quality reduction in these images[34].The iris lens should be kept erraticto attain an enhanced visualization. All the cameras can be accessed separately and their control is independent, so users or the firefighter gets access to the camera and administer it without any trouble.

IV. Conclusion

This technology can also be useful in breeding of confined animals in precision zoo, where the sensor nodes should propel information about the fauna. To manage and check the environmental factors the wireless sensors and actuators are indispensable. For a WSN to make distributed measure, dispersalof sensors all over the greenhouse using distributed clustering has been done. This paper reveals some solemn issues when a wireless sensor network is uncovered to real world environment to check and control parameters like temperature, humidity, smoke, CO_2, light and greenhouse gases and how distributed clustering mechanisms can be integrated within this monitoring procedure.

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