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Research Article

Environmental Monitoring and Greenhouse Control by Distributed Wireless Sensor Network

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Abstract: A sensor is a miniature component which gauge physical parameters from the environment. Sensors measure the physical parameters and transmits them either by wired or wireless means. In wireless medium the sensor and its allied components are called as node. A wireless sensor node is self-assured by a processor, local memory, sensors, radio, battery and a base station accountable for receiving and processing data collected by the nodes. They carry out cooperative activities due to limited resources and nowadays, the applications of these networks are copious, varied and the applications in agriculture are still budding. One interesting purpose is in environmental monitoring and greenhouse control, where the crop conditions such as weather and soil do not depend on natural agents. To control and observe the environmental factors, sensors and actuators are necessary. Under these conditions, these devices must be used to make a distributed measure, scattering sensors all over the greenhouse using distributed clustering mechanism. This paper reveals an initiative of environmental monitoring and greenhouse control using a sensor network. The hardware realization shows periodic monitoring and control of greenhouse gases in an enhanced manner. Future effort is concentrated in application of the same mechanism using wireless sensor network.
Keywords: Sensor, sensor nodes, wireless sensor network (WSN), greenhouse control, environmental monitoring, CO_2 monitoring, distributed clustering.

INTRODUCTION

A sensor is bright to convert physical or chemical readings gathered from the environment into signals that can be calculated by a system. A multi sensor node is intelligent to sense several magnitudes in the same device. In a multi sensor, the input variables may be temperature, fire, infrared radiation, humidity, smoke and CO_2. A wireless sensor network could be an functional architecture for the deployment of the sensors used for fire detection and verification. The most imperative factors for the quality and yield of plant growth are temperature, humidity, light and the level of the carbon dioxide. Constant monitoring of these ecological variables gives information to the cultivator to better understand, how each aspect affects growth and how to administer maximal crop productiveness. The best possible greenhouse [3] climate modification can facilitate us to advance productivity and to get remarkable energy saving, predominantly during the winter in northern countries. In the past age band, greenhouses it was enough to have one cabled dimension point in the middle to offer the information to the greenhouse automation system. The arrangement itself was typically simple without opportunities to supervise locally heating, light, ventilation or some other actions which were affecting the greenhouse interior climate. The archetypal size of the greenhouse itself is much larger than it was before, and the greenhouse facilities afford several options to make local adjustments to light, ventilation and other greenhouse support systems.

However, added measurement data is also needed to put up this kind of automation system to labor properly. Increased number of measurement points should not dramatically augment the automation system cost. It should also be probable to easily alter the location of the measurement points according to the particular needs, which depend on the definite plant, on the possible changes in the external weather or greenhouse arrangement and on the plant placement in the greenhouse. Wireless sensor network can form a helpful part of the automation system architecture in contemporary greenhouses constructively. Compared to the cabled systems, the setting up of WSN is fast and easier to relocate the measurement points when needed by immediately moving sensor nodes from one location to another within a communication range of the coordinator gadget. If the greenhouse vegetation is high and dense, the small and light weight nodes can be hanged up to the branches.

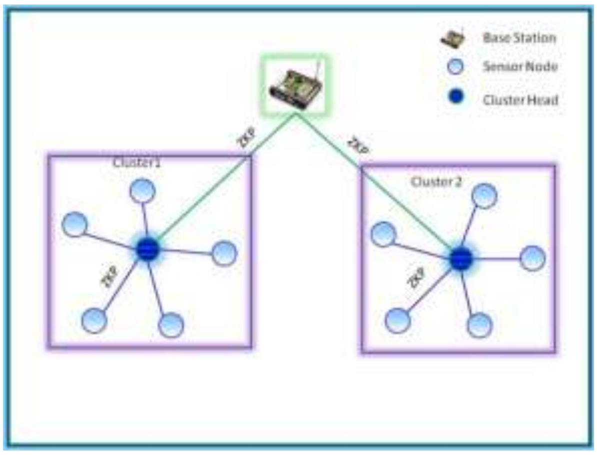

Fig-1: Clustering in a sensor network

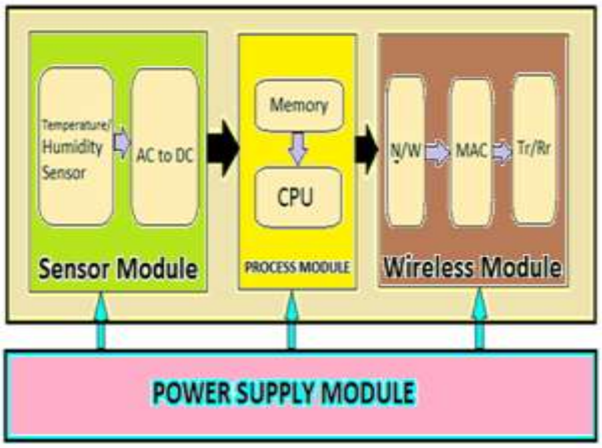

Fig-2: Assorted components of a wireless sensor node

WSN maintenance is also relatively inexpensive and trouble-free. The only other costs occur when the sensor nodes run out of batteries (figure 2) and the batteries need to be recharged or replaced. In this work, the very first steps towards the wireless greenhouse automation system by building a wireless measuring arrangement for that purpose is taken and by testing its feasibility and reliability with a straightforward experimental setup. Clustering [11, 12] may be centralized or distributed, based on the array of CH. In centralized clustering (figure 1), the CH is preset but in distributed clustering CH has no permanent architecture. Distributed clustering mechanism is used for some classified reasons like sensor nodes prone to failure, better collection of data and minimizing redundant information. Hence these distributed clustering mechanisms cover enormously self-organizing capability.

RELATED WORKS IN WSN

Military applications are incredibly closely linked to the consciousness of wireless sensor networks. In fact, it is awfully harsh to say for sure whether motes were developed because of military and air defense needs or whether they were made-up separately and were subsequently useful to army services. Regarding military applications, the province of concentration extents from information collection, normally, to enemy tracking or battlefield surveillance. For example, mines may perhaps be regarded as unsafe and outdated in the future and may be replaced by thousands of remote sensor nodes that will detect an imposition of unreceptive units.

Open-air monitoring is an added celestial area for applications of sensors networks. One of the mainly delegate examples is the action of sensor nodes on Great Duck Island [8]. This sensor network has been used for atmosphere monitoring. The sensor nodes used were gifted to sense temperature, barometric pressure and humidity [1, 2]. In adding together, passive infrared sensors and photo resistors were affianced. The arrangement was to watch the natural environment of a bird and its activities according to climatic changes. For that reason, a number of motes were installed within birds' burrows, to mark out the bird's presence, while the rest were deployed in the close by areas. Data are aggregated by the employment of nodes and are conceded through to a gateway.

Supervision of costly possessions like equipment, machinery, diverse types of stock or products can be a quandary. The problem is highly distributed, as these companies expand all over the globe. A gifted technique to attain asset tracking and deal with this trouble is believed to be with the exercise of sensor networks. The application of wireless sensors in petroleum bunks and chemical warehouses refers to warehouses and freight space administration of barrels.

Fitness science and the health care arrangement can also yield from the employment of wireless sensors. Applications in this group include telemonitoring human physiological information remotely, tracking and monitoring of doctors and patients within a hospital, medicine superintendent in hospitals, etc. In Smart Sensors, retina prosthesis flake consisting of 100 micro sensors are built within the human eye. This allows patients with scarce vision to see at an adequate level.

Robotic applications [9, 10] previously implemented are the unearthing of level sets of scalar fields using portable sensor networks and replication of the function of bacteria for looking for and discovering dissipative gradient sources. The tracking of a beam source is completed with a few of the effortless algorithms. In addition, an answer to the coverage crisis by robots and motes is accomplished for chunky measurements over a broad area. The association of both static and mobile networks is accomplished with the aid of mobile robots, which journey around the environment and set up motes that act as beacons.

Landslide discovery employs scattered sensor system for predicting the happening of the landslides. The deliberation of predicting landslides by means of sensor networks arose out of a necessity to mitigate the stain caused by landslides to human lives and to the railway networks. A blend of techniques from earth sciences, signal processing, scattered systems and fault-tolerance is used. One solitary peculiarity of these systems is that it combines several distributed systems techniques to contract with the complexities of a distributed sensor network environment where connectivity is disadvantaged and power budgets are very constrained, while fulfilling real-world requirements of protection. Generally these methods use a set of low-priced single-axis strain gauges attached to cheap nodes, all with a CPU, battery and best wireless transmitter block.

Forest fires, also recognized as feral fires are wild fires occurring in wild areas and cause chief damage to natural resources. Universal causes of forest fires squeeze lightning, individual carelessness and revelation of fuel to tremendous heat and aridity. It is well identified that in few cases fires are ingredient of the forest ecosystem and they are vital to the life cycle of native habitats

Sensor-Clouds can be used for fitness monitoring by using a measure of simply obtainable and most often wearable sensors like accelerometer sensors, propinquity and temperature sensors and so forth to collect patient's health-related statistics for tracking sleep action pattern, body temperature and other respiratory conditions. These wearable sensor devices should have sustain of Bluetooth's wireless interface, Ultra wideband and so forth interface for streaming of information, linked wirelessly to some smart phone through the interface. These smart phone devices performs like a gateway between the remote server and the wireless sensor through the internet.

EXPERIMENTAL SETUP IN A GREENHOUSE

A. The Greenhouse Environment

A contemporary greenhouse [4-6] can consist of copious parts which contain their own confined climate variable settings. As a result, a quantity of measurement points are also needed. This group of environment is demanding both for the sensor node electronics and for the short-range IEEE 802.15.4 wireless network, in which communication choice is greatly longer in open environments.

B. Sensors

Speedy response time, squat power consumption and tolerance beside moisture climate, relative humidity and temperature sensor forms an idyllic preference and explanation for the greenhouse environment. Communication among sensor nodes can be carried out by IIC interface. Luminosity can be measured by light sensor, which converts light intensity to equivalent voltage. Unstable output signal is handled by low-pass filter to acquire exact luminosity values. CO_2 measuring [7] takes longer time than other measurements and CO_2 sensor voltage supply have to be within little volts. The carbon dioxide assessment can be read from the ensuing output voltage. Operational amplifier raises the voltage level of weak signal from the sensor.

C. Greenhouses

A greenhouse is a pattern covering the ground frequently used for growth and progress of plants that will revisit the owner's risk, time and capital. This exhibit is mounted with the purpose of caring crop and allowing a better environment to its advancement. This defend is enough to guarantee a higher quality in production in some cases. However, when the chief idea is to achieve a superior control on the horticulture development, it is necessary to examine and control the variables that influence the progress of a culture. The chief role of a greenhouse is to offer a more compassionate environment than outside. Unlike what happens in customary agriculture, where crop conditions and yield depend on natural resources such as climate, soil and others, a greenhouse ought to promise production independent of climatic factors. It is noteworthy to view that even though a greenhouse protects crop from peripheral factors such as winds, water excess and warmth it may root plentiful problems such as fungus and extreme humidity. Therefore, mechanisms to inspect and manage a greenhouse environment are unbelievably vital to get better productivity. To obtain higher productivity and quality, enhanced control system is necessary and as a result the fabrication costs also gets reduced. The chief elements concerned in a greenhouse control system are: temperature, humidity and concentration of CO_2.

D. Temperature

Temperature is one of the main key factors to be monitored since it is unswervingly related to the development and progress of the plants. For all plant varieties, there is a temperature variety considered as a best range and to most plants this range is comparatively varying between 10ºC and 30ºC. Among these parameters of temperature: intense temperatures, maximum temperature, minimum temperature, day and night temperatures, difference between day and night temperatures are to be cautiously considered.

E. Water and Humidity

An additional significant factor in greenhouses is water. The absorption of water by plants is associated with the radiation. The deficient in or low level of water affects growth and photosynthesis of these plants. Besides air, the ground humidity also regulate the development of plants. The air humidity is interconnected with the transpiration, while the ground humidity is linked to water absorption and the photosynthesis. An atmosphere with tremendous humidity decreases plants transpiration, thereby reducing growth and may endorse the proliferation of fungus. On the other hand, crouch humidity level environments might cause dehydration.

F. Radiation

Radiation is an elementary element in greenhouse production and sunlight is the key starting place of radiation. It is an imperative component for photosynthesis and carbon fixing. Momentous radiation features are intensity and duration. The radiation intensity is linked to plant development and the duration is explicitly associated with its metabolism.

G. CO_2 Concentration

CO_2 is an indispensable nutrient for the plant development, allowing the adaptation of carbon. The carbon retaining process occurs through the photosynthesis when plants take away CO_2 from the atmosphere. During photosynthesis, the plant use carbon and radiation to produce carbohydrate, whose purpose is to permit the plant development. Therefore, an enriched air environment should add to plant growth, but it is also vital to note that an intense carbon level may turn the environment poisonous.

THE PROPOSED MODEL

A solution to the existing drawbacks can be found out from this proposed model. The proposed model is implemented in hardware, tested and the results show an excellent improvement in the sensing parameters when compared to the existing set of environmental monitoring and greenhouse control models. Sensor arrays like temperature sensor, light sensor, humidity sensor and CO_2 sensors are incorporated in the board. The sensed data is processed by the micro controller and displayed in the LCD display. Wireless transmission of the parameters is accomplished by a zigbee module that sends information to the remote monitoring station periodically. To control and monitor the environmental variables planned in an earlier section, sensors and actuators capable of measuring and controlling the values inside the greenhouse are essential. Generally, a greenhouse control is implemented just by approximating a calculated cost to a reference or ideal cost. Figure 3 shows the basic block diagram of the proposed model. Due to cost considerations, the proposed model uses sensor network instead of wireless sensor network. The sensed data is forwarded to the gateway. The gateway then forwards the data to the remote monitoring base station. The base station is a remotely located software configured computer, where the monitored details are periodically visualized to carry out further control actions.

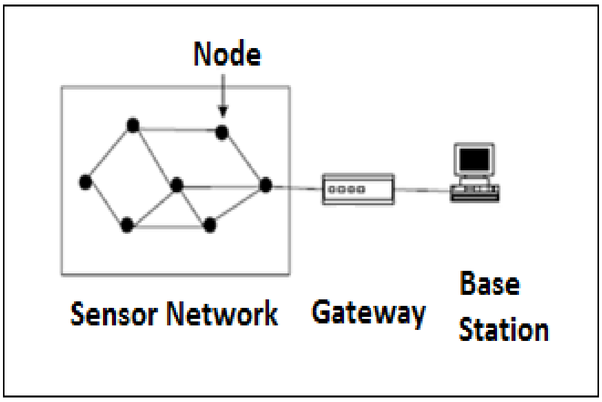

Fig-3: Block diagram of the proposed model

In the proposed model, the ideal evaluation depends on the culture and type of plant. Control systems can be separated into either centralized or distributed systems. In a centralized system a single constituent is accountable for gathering and processing the data. So, every components of the system are connected to this private element. In a distributed control system, connections between nodes and the information processing is distributed amid the system components. The crucial advantages of a distributed system may include: Reliability: a component stoppage affects barely part of the structure, Expansion: the possibility of adding up of a new component without massive changes in the system, Flexibility: changes in the process related to the components involved in these basic operations. The major difficulty of these technologies is that they are not developed for WSN and they do not present mechanisms to perk up energy efficiency.

In this way, it is credible to check all places inside the greenhouse, identifying not only restricted values as in many applications, but checking numerous real world and distributed values. Therefore, the greenhouse control ought to be improved, allowing a resolution in a way that the absolute environment can be adjusted as close as feasible to a set point. It is indispensable to observe that, in most applications the sensors are positioned in a point of a greenhouse and the measures gained are used to direct the entire greenhouse. Figure 4 shows the experimental setup for environmental monitoring.

Fig-4: Experimental setup for environmental monitoring

Thus, the use of sensor in a greenhouse environment authorizes a real-time monitoring and an improved measurement through convenient distribution. The collected data in the system proposed is sent to a base station situated outside the greenhouse. The base station is linked by a gateway. With the execution of this architecture, each node is answerable for data collecting through its sensors and sending it to its neighbors until all collected data emerge at the base station. The gateway normally uses wireless and Ethernet communication. The base station is accountable for managing the collected data, so some greenhouse control softwares and some wireless actuators are necessary here. In this application, node protection is necessary to shun the damage by water and inputs. It is imperative to highlight that the use of wireless sensors and actuators is beneficial to make the system installation trouble-free and to obtain suppleness and mobility in the nodes prototype. The difficulties in applying WSN in agricultural applications include higher costs and short of standardization on WSN communication protocols. Due to cost constraints, the proposed model is designed with ordinary sensors. In future, the same sensor network will be simulated in NS-2 for a distributed clustering mechanism. Wireless sensor network with temperature, moisture and light sensing with advanced capabilities will be implemented in real-time environment for green house monitoring in future.

DISCUSSIONS

The major contributions of this manuscript are as follows. The devise and implementation of large-scale and long-term CO_2 monitoring sensor network has been discussed. A low-cost sensor deployment strategies with guaranteed recital which addresses the sensor deployment problems in the on-hand models has been proposed. Hardware implementation of these model has been done and the parameters are periodically monitored with few variety of sensors.

CONCLUSION AND FUTURE WORK

A model of agricultural application using sensor networks for greenhouses monitoring and control has been presented. The WSN technology, although under development, seems to be gifted mainly because it allows real time data acquisition. However, for such agricultural relevance to be developed, some technological challenges should be determined. A greenhouse is a controlled environment and does not need a lot of climatic parameters to be controlled. The use of this technology in large scale seems to be something for the near future. In this application, huge climatic parameters can be monitored using the sensors obtainable. As a greenhouse is fairly small and controlled environment, and energy is a partial resource, the likelihood of replacing batteries or even resorting to a sturdy energy source adaptation is a helpful feature. This paper reveals a plan of environmental monitoring and greenhouse control by means of a sensor network. The hardware implementation shows periodic monitoring and control of greenhouse gases in an improved manner. Future research is concentrated in application of the same mechanism using wireless sensor network. This knowledge can also be applied in breeding of cramped animals in precision zoo, where the sensor nodes should propel information about animal temperature, pressure and additional vital signals to guarantee a strong environment to animals. In order to attain better energy efficiency, this mechanism will be implemented in real-world wireless sensor network, with a well-known energy efficient distributed clustering mechanism (HEED).

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