RESEARCH ARTICLE

A review on applications of wireless sensor networks in agriculture

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ABSTRACT

The Wireless Sensors Network (WSN) in these days is broadly used to build Decision Support System (DSS) to beat numerous issues in the present reality. A standout amongst the most intriguing fields that includes WSN is Agriculture. Because of progression in innovations, sensors are getting to be distinctly required in practically every field of life. Agribusiness is one of such spaces where sensors and their systems are effectively used to get various advantages. Choice of sensors and their effective usage to take care of agricultural issues has been a challenging task. The aim of this paper is to audit the need of wireless sensors in Agriculture. The technologies used in agriculture and their applications in various parts of agribusiness and to report the difficulties of WSN in the field of agriculture.

Key words: Wireless Sensor Networks, Agriculture, Farming, Sensor Networks.

INTRODUCTION

Agriculture has assumed a key part in the improvement of human progress. Because of the expanded request of nourishment, individuals are attempting to put additional endeavours in agriculture. Utilization of various innovations towards farming is one of such activities. Aside from utilization of scientific innovations in farming, information innovation is now being intensely practiced around there. Utilization of sensors and their systems is supporting agribusiness sharpens an extremely positive course. For sensor based agriculture, varieties of new innovations are presently being used like Precision Agriculture (PA), Smart Agribusiness, Variable Rate Technology (VRT), Precision Farming, Global Situating System (GPS) Agriculture, Farming by Inch, Information- Concentrated Agriculture, Site Specific Crop Management and so forth however the basic idea in every one of them is same. Progressions of advancements pointed the extent of sensors to such degree that empowered them to be used in variety of the spaces of human life. Because of the noteworthiness of sensor innovation, a few issues identified with sensors and their systems are in research. Energy Constraint, limited processing power, little memory and information security are a portion of the considerable issues of sensor systems for which specialists proposed a few solutions. The point of this paper is to audit the need of wireless sensors in parts of agriculture.

Applications of wireless sensor networks

Organization of wireless sensors and sensor networks in agribusiness and food industry is still toward the starting stage.

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Applications can be grouped into five classifications: : (1) environmental monitoring, (2) precision agriculture, (3) machine and process control, (4) building and facility automation and (5) traceability systems. Here we discuss about the first two applications.

Environmental monitoring

Disregarding the quick improvement of PC innovation, field estimations of condition factors, such as climate information and geo-referenced water quality information still rely on upon stationary sensors and data loggers, pencils and paper note pads, which are work serious and vulnerable to recording mistakes amid interpretation.

Weather monitoring

The Discovery Channel (2003) detailed an utilization of a wireless sensor network in a vineyard in BC, Canada. Sixty-five bits were introduced in a 1-section of land to remotely report temperature, moisture and daylight power to a focal PC each 5 min. The proprietor could without much of a stretch screen every region of the vineyard progressively to maintain a strategic distance from ice, oversee water system, and manage irrigation and fertilizer. A solar-powered wireless sensor network by Crossbow Innovation Inc. (2004) to give climate data in fields. A remote application server transferred information from the sensor system to nearby clients by means of a WLAN and wireless clients by means of cell system and the Web.

Irrigation management

For modern age cultivating there is need of altered water system strategy which enhances the water utilization. The

inadequate and irregular rainfall, exhaustion of ground water level and shortage of water are the inspirations for changed techniques. The water system analysis should be possible in view of climate, plant and soil moisture base. Additionally the utilization of water for the harvest of crops will likewise accommodating for the development of yield and providing most extreme plant nutrients that are sufficient for the plant growth. As indicated by the data gave by it there will be choice identified with manures and pesticides application, water system and so on will be taken.

Precision Agriculture

Generally agribusiness is drilled by playing out a specific assignment, for example, planting or reaping, against the schedule. Be that as it may, by gathering continuous information on climate, soil and air quality, edit development and even hardware and work expenses and accessibility, precise investigation can be utilized to settle on more better choices. This is known as precision agriculture. Precision agriculture is organized into four stages, such as *Data Collection* Geo-locating a field empowers the agriculturist to overlay data assembled from examination of soils and remaining nitrogen, and data on past yields and soil resistivity.

Geo-location is done in two ways:

1. The field is laid out utilizing an in-vehicle GPS recipient as the agriculturist drives a tractor around the field.
2. The field is laid out on a base guide got from satellite view images. The base pictures must have the correct level of determination and geometric quality to guarantee that geo-location is adequately precise.

Variables: Intra and between field inconstancy may come about because of various variables. These incorporate climatic conditions (hail, drought, rain, and so on), soils (surface, profundity, nitrogen levels), weeds and sickness. Perpetual pointers—mostly soil markers—give agriculturists data about the principle ecological constants. Guide markers permit them toward track a harvest's status, i.e., to see whether infections are occurring, if the product is experiencing water stretch, nitrogen stress, regardless of whether it has been harmed by ice . This data may originate from climate stations and different sensors (soil electrical resistivity, identification with the bare eye, satellite images, and so on). Soil resistivity estimations joined with soil examination make it conceivable to quantify dampness content.

Strategies: Utilizing soil maps, farmers can seek after two procedures to conform field inputs:

Predictive approach: Depends on static markers (soil, resistivity, field history etc).

Control approach: data from static markers is frequently refreshed amid the harvest cycle by:

Sampling: measuring biomass, measuring leaf chlorophyll content, measuring organic product, and so forth.

Remote sensing: measuring parameters like temperature (air/soil), mugginess (air/soil/leaf), wind or stem distance across is conceivable on account of Wireless Sensor Networks.

Satellite remote detecting: multispectral imagery is gained and prepared to determine maps of yield biophysical parameters. decisions might be founded on decision support system a computer based system for efficient systems.

Implementing: Practices Utilization of yield administration choices requires farming equipments that supports variable-rate innovation (VRT).Precision agriculture utilizes innovation on farming hardware (e.g. tractors, sprayers, gatherers).GPS and GIS geographic data frameworks. i.e., software that contains all the accessible information, variable-rate cultivating agri equipment (seeder, spreader).

Livestock Monitoring

Advanced animal production has changed lately because of the utilization of exact instruments. Consequences of late research have been utilized as contributions to preventive diagnostics and improvement of decision making software in a few areas. WST has been utilized as another system for measuring center body temperature that are minimum spreading and give consistent, remote, real time information. Together with body temperature WSN can acquire the oxygen immersion of cows' blood utilizing a pulse oximeter, location (GPS), encompassing temperature and breath. Assessment of animal welfare can likewise be determined by wireless checking and empower the maker to settle on the correct decisions based on real time management. Nadimi *et al*. tended to and tackled the issue of on-line observing of dairy animals in a broadened zone, utilizing ZigBee based wireless sensor systems. An investigation of wireless sensor systems connected to the checking of animal conduct in the field is depicted. The issue of online observing of dairy animals' essence and field time in a broadened territory secured by a piece of new grass utilizing wireless sensor systems has been addressed. Observing and control of the environment of indoor condition is critical for animal wellbeing and welfare and specifically impacts profitability and quality. Ventilation in the stables must be overseen keeping in mind the end goal to evade long haul over-basic presentation of the animals to ammonia, causing stress, pour well being and lessened efficiency. Cai *et al*. displayed a wireless, wireless question ammonia sensor that can track both low and high concentrations of ammonia. In the meantime, ventilation and warming must be limited with a specific end goal to save energy while keeping temperatures at a sufficient level. Cugnasca *et al*. assessed the ability and helpfulness of WSN connected to monitor natural factors in an animal housing facility. The nodes were travelled through the facility to decide diverse profiles of temperature, humidity and iridescence.

Precision Viticulture

Precision viticulture is all about identifying and maintaining differences within vineyards, improve vineyard execution, specifically, increasing grape yield and quality while limiting ecological effects and hazard. This is managed by measuring nearby variety in factors that impact grape yield and quality (soil, geology, climate, vine health etc) and applying suitable viticulture practices. precision viticulture depends on the preface that high in-field changeability for factors that influence vine development and grape maturing warrants intensive managements altered by local conditions. Precision viticulture is considered to be at least one of the geospatial advances and other related devices, instruments and procedures

that utilization spatial area for gathering, handling, examining, and imagining natural information gathered in a vineyard. precision viticulture is thought to be a way to deal with wine creation in view of acknowledgment of the way that the efficiency of vineyards and individual pieces inside a vineyard can be characteristically factor over space and time on account of contrasts in geology, soil moisture, plant health and microclimate management practices. Differences in environment at last prompts to the differences in grape yield (amount) and quality and also wine production. There are four noteworthy parts of innovation utilized for precision viticulture management. They are global positioning systems (GPS), remote sensing, geographical information systems (GIS), and variable rate application (VRA). The global positioning systems (GPS) is a satellite star grouping used to geo-reference spatially referenced vineyard information (e.g., soil tests, yields, and so forth). Geographic information system (GIS) empowers the advantageous capture, storage maintenance, control, and administration of spatially adjusted, geographic information layers. Remote sensing refers to capturing of computerized view of the Earth's surface via satellite. Variable-rate application (VRA) portrays any innovation, which empowers producers to differ the rate of inputs.

Technologies and wireless sensor networks

A WSN is a framework containing radio recurrence (RF) transceivers, sensors, microcontrollers and power sources. Late advances in wireless sensor networking innovation have prompted the improvement of minimal cost, low power, multifunctional sensor nodes. Sensor nodes empower environment detecting together with information processing. Instrumented with many kinds of sensors, for example, temperature, humidity and unpredictable compound detection, permit observing of various situations. They can coordinate with other sensor frameworks and swap information with outside users. A general WSN protocol comprises of the application layer, transport layer, network layer, datalink layer, physical layer, power control system, mobility management system and the task administration system. At present two standard innovations are accessible for WSN: ZigBee and Bluetooth. Both work inside the Industrial Scientific and Medical (ISM) band of 2.4 GHz, which gives permit free operations, tremendous range distribution and overall compatibility. Multi-hop correspondence over the ISM band may well be conceivable in WSN since it devours less power than conventional single hop communication. It is additionally conceivable to make a WSN utilizing Wi-Fi (IEEE 802.11), yet this protocol is generally used in PC-based frameworks since it was created to expand or substitute for a wired LAN . Its energy utilization is somewhat high, and the short self-sufficiency of a battery control supply still remains a critical burden.

Bluetooth

Bluetooth (IEEE 802.15.1) is a wireless protocol for short-range communication in a personal area network (PAN) as a cable swap for cell phones. It utilizes the 868 and 915 MHz and the 2.4 GHz radio bands to impart at 1 Mb for every second between up to seven devices. Bluetooth is mostly intended to increase ad hoc network. Some of its regular capacities are passing and synchronizing information, e.g. between a PDA (personal digital assistant) and a PC, remote access to LANs, and association with the web. It utilizes

frequency-hopping spread-spectrum(FHSS), which transmits information over various frequencies at various time periods. Bluetooth utilizes an master slave-based MAC (medium access control) protocol.

Zigbee

The ZigBee standard is based on the IEEE 802.15.4 standard. The IEEE 802.15.4 standard characterizes the physical and MAC (Medium Access Control) layers for low-rate personal area network. The physical layer underpins three frequency groups with various gross information rates: 2,450 MHz (250 kbs-1), 915 MHz (40 kbs-1) and 868 MHz (20 kbs-1). It additionally supports functionalities for channel determination, connect quality estimation, energy estimation and clear channel evaluation. ZigBee institutionalizes both the system and the application layer. The system layer is responsible for sorting out and providing routing over a multi-hop network, indicating distinctive network topologies: star, tree, peer-to-peer and mesh. The application layer gives a structure for distributed application advancement and communication. Apart, from agriculture it is generally used as a part of home building control, computerization, security, PC peripherals, therapy monitoring. These applications require an innovation that offers long battery life, dependability, programmed or self installation, the capacity to effectively include or expel arrange nodes, signals that can go through dividers and roofs and a low framework cost.

RFID

RFID is a rising innovation that makes use of WSN. The convention was initially created for short-range identification, commonly covering the 2 mm - 2 m range, and has been advanced as the exchange of innovation for the optical bar code found, with the utilization of EPC (Electronic Product Code). RFID can enable vitality to enter certain products and to pursue a label that is not noticeable. There are numerous different protocols utilized as a part of the different RFID frameworks, some utilizing the lower end of the range (135 KHz) and others utilizing the super high frequency (SHF) at 5.875 GHz:There are even different standards in RFID. RFID system consists of three primary segments: the tag or transponder, the reader or transceiver that read and write information to a transponder, and the PC containing database and data administration programming . RFID labels can be dynamic, semi-passive. Inactive and semi-passive RFID send their information by reflection of the electromagnetic field that was produced by the Reader. The ordinary reading range is between 10 cm and 3 m. The battery of semi-passive RFID is just used to control the sensor and recording logic. The communication of dynamic RFID is fuelled by his own battery. This empowers higher signal quality and stretched communication range of 100 meters; yet the usage of dynamic correspondence requires bigger batteries and more electronic parts. The common cost of dynamic RFID is between five or ten times the cost of semi-passive one. RFID has been effectively applied to food and supply chain management due to its capacity to recognize, order, and deal with the goods. Likewise, electronic ID of cows utilizing RFID is a typical practice in many fields. However recent improvements in RFID equipment equipped with sensors broaden its scope of application. There are business active and semi-passive labels that can gather temperature data. Other semi-passive tags equipped with sensor are a work in progress, similar to

humidity, vibration, light and concentration of gasses, for example, acetaldehyde or ethylene. In agriculture, dynamic tags are very intriguing, particularly for animal behaviour. They consequently send vibrations, so the animals can be recognized by even from very far distance. This capacity is ensured by utilizing a power battery. These devices can be utilized to observe animals in average size outdoor pens, giving advanced information that can be computerized easily.

Need for wireless sensor networks

WSN are currently littler, modest and with intense preparing than prior hubs. In spite of the fact that the most essential part of WSN is vitality productivity, a typical method is Dynamic Power Management (DPM) where a node can be moved between various operational modes. Fundamental preferences of Wireless Sensor Systems are unwavering quality, cost and vitality adequacy, exactness, adaptability and simplicity of arrangement even in unforgiving spots. The Key qualities and advantages of Remote Sensor Systems (WSN) are recorded underneath

Adaptability: A key normal for a WSN is its capacity to self-deal with, that is, it can adjust to changes in the system, incorporating changes in topology, arrange size, thickness, and activity qualities.

Reliability: Fixed quality is a typical necessity for most correspondence systems. In Wireless Sensor Arrange, unwavering quality is expanded by recognizing and retrieve from transmission blunders and impacts.

Operability in unforgiving condition: Sensor nodes can be sent in brutal and distant condition that makes the sensors more powerful.

Coverage zone: Versatile and proficient sensor system could traverse a more noteworthy geographic territory with no antagonistic effect on the general system throughputs, performance and cost. Least human association make conceivable of having less interference of the framework.

Connectivity: Numerous sensor systems can be associated through nodes, even with wired systems. The bunching of systems empowers every individual system to concentrate on particular ranges or occasions and share just pertinent data.

Challenges

The primary difficulties to advance are:

Equipment Cost: The present cost of every individual sensor unit is still high. Financially accessible stages cost in the request of Rs. 5000 for every unit with temperature, mugginess furthermore, light sensors when purchased in substantial amounts. Those sensors ready to track human versatility inside structures are costing around Rs.15000 per unit.

Battery Life: The sensor nodes are portrayed especially by their restricted power and memory limits. The power is utilized to be a key parameter for any approach assuming that sensor nodes batteries are unchangeable and not rechargeable frequently. Thus due to the large usage of batteries it becomes extremely difficult to recharge it frequently.

Framework Architecture: There is no bound together framework and organizing engineering that is steady and develop enough to fabricate diverse applications on top. A large portion of the applications furthermore, look into models are vertically coordinated with a specific end goal to expand execution.

Connectivity: Wireless correspondence in indoor situations is still very eccentric utilizing low-control utilization RF handsets and also the main problem is connecting between the long distance nodes, specifically in mess situations normal inside structures, with numerous meddling electromagnetic fields, for example, the one delivered by lifts, apparatus and PCs, among others.

Programmability: Some type of system re-programmability is alluring; doing as such in vitality and correspondence preservationist shape remains a test.

Security: The security difficulties are at many levels.

- From the framework perspective, it is important that the data gave by the nodes be validated and the uprightness confirmed, since this data gives the input circle to costly mechanism controlling force utilization in the structure.
- From the clients' perspective, it is additionally important that this data can't be effortlessly spoofed and remains secured in the back end processor, since it might influence the protection of clients.

Livestock Infection Control: The infection condition is considered here with regards to expanding productivity from the range in order to make putting resources into its advantageous supportability. Again the utilization of indigenous information to control malady is to be energized. Otherwise, vital mass inoculations against regular infections and utilization of anthelmintics would enormously build survival rates. Routine vaccinations with periodical checkups regularly are recommended.

Vineyard Crop Management: Major Challenges for grape cultivating are downy mildew and meal bug which spreads right away and are difficult to control. As the grape is costly, Farmer should be exceptionally watchful from the underlying stage till harvesting to stay away from contamination of contagious malady and pest. However to prevent the infection agriculturist needs to apply fungicides and pesticides and also by frequent monitoring of the crops from the earlier stage.

Modern applications

As of late, with the coming of the new specialized ideas for example, sensor-cloud innovation, huge information examination, Internet of Things (IoT), new applications are imagined. We quickly depict such ideas, and enrol a couple of potential cutting edge applications in the accompanying.

Sensor-cloud computing

sensor-cloud computing alludes to the on-field WSN applications engaged with distributed computing This incorporated structure benefits the WSNs with enhanced handling power and capacity limit. Moreover, sensor cloud enhances the data management and get to control while expanding the resource usage. some of potential application

are, A cloud-empowered storage of spatial variety of soil and ecological profile regarding different seasons is have to be created. Crop wellbeing checking and yield forecast utilizing portable sensor-cloud storage. Designing a sensor-cloud controlled smart water system framework for substantial fields. To plan a sensor-cloud worked condition control framework for off-season generation of vegetables and blossoms in nursery cultivating.

Big-data

Big-data examination strategies are connected to find significant understanding from huge volume of information with different information sorts. Enormous information investigation based strategies are useful for finding hidden connections, to improve business patterns, customer preferences, identifying crimes and environmental disasters, and so on. We list couple of huge information application for the rural area as, Building crop development and infection management models. Easy cultivating instruments control for large scale fields. Decision support service to enhance crop yield with ideal cost with respect to large scale agriculture and climatic conditions.

Internet of Things

The IoT characterizes "things" which are able to for distinguishing, imparting and interacting with environment. IoT providesflexible control mechanism for on-field parameters in realtime. Because of this, IoT is a potential answer for different farming applications. some applications are, Cost effective agricultural chain to store network management utilizing RFID labels. Remote checking of animal movements in open fields. Remote control and planning of pesticide showers at an customer characterized rate and time. Leak identification and remote water stream control in vast scale farming field water supply.

Conclusion

The study of the current works guides us to the following concluding comments. The present WSN system offers best in class for water system administration, identify infection and forecast, vineyard accuracy cultivating and precision agriculture generally. Simplified minimal effort, and scalable frameworks with low cost are required. With the appearance of current advancements, there exist a great deal of extension for improving new and productive technologies.

In particular, minimal effort and cost arrangement with components like self-governing operation, low maintenance. Generally speaking, future pre planning with better technologies and new innovations need to be implemented for the achievement of these applications particularly to overcome the issues.

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