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An intellectual data-mining method using wireless sensor networks for water maintenance in agriculture/cultivation during drip irrigation: A Case Study.

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ABSTRACT
Agricultural data analysis is an important challenge for the data mining community present not only in India but also in the world. This is done to the fact that majority of the cultivation lands in the globe suffer highly from shortage of irrigation water. In such a scenario, drip irrigation techniques have been developed by researchers to reduce the water consumption in dry areas. However, due to the lack of guidelines and systematic techniques to utilize the water and electricity in optimistic manner, new line the agricultural sector faces water problem in many places. Therefore, the overheads of farmers using the conventional drip irrigation have become high and they have to manually visit and monitor the lands frequently. Agricultural data mining provides techniques for transporting water crops optimally in order to maximize the amount of crops produced. Agricultural data can be collected more efficiently by the use of sensors for data collection and also for effective analysis. Moreover, Wireless sensor networks are used in many applications like agricultural activities, natural disaster management systems, military applications, forest fire detection systems, deep ocean navigations, industrial automations, health care systems for elder people, smart home newline automation applications, etc,. A smart irrigation system can be built with smart sensor networks for collecting field values and can be analyzed using rules for effectively watering the plants. Hence, a new sensor network assisted irrigation system and rule based analysis model have been developed to enhance the efficiency of water usage.

Keywords: Agricultural, Data Mining, Drip Irrigation, Engineering and Technology, Engineering Multidisciplinary, Water Conservation, Wireless Sensor Networks.

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INTRODUCTION

Agricultural data analysis is an important challenge for the data mining community present not only in India but also in the world. This is done to the fact that majority of the cultivation lands in the globe suffer highly from shortage of irrigation water [1]. Drip irrigation techniques have been developed to reduce the water consumption [3] in dry areas. However, due to the lack of guidelines and systematic techniques to utilize the water and electricity in optimistic manner, the agricultural sector faces water problem in many places.

Therefore, the overheads of farmers using the conventional drip irrigation have become high and they have to manually visit and monitor the lands frequently. Agricultural data mining provides techniques for transporting water crops optimally in order to maximize the amount of crops produced. Agricultural data can be collected more efficiently by the use of sensors for data collection and also for effective analysis. Moreover, Wireless Sensor Networks are used in many applications like agricultural activities, natural disaster management systems, military applications, forest fire detection systems, deep ocean navigations, industrial automations, health care systems for elder people, smart home automation applications, etc,.

Many agricultural activities can be highly enhanced by using sensor networks and data mining techniques. One of these activities is the regulation of the quantity of water in cultivated fields. Moreover, wireless sensor network have become a more emerging technology in precision agriculture [6] during the recent years. The important issue in the design of wireless sensor networks is the utilization of energy and to enhance the lifetime of the sensor nodes.

AGRICULTURE IN INDIA

The word agriculture is derived from two Latin words 'Ager' and 'Cultura.' Ager means land or field and Cultura means cultivation. Therefore, the term agriculture means cultivation of land. Moreover, Agriculture is the science and art of producing crops and livestock for economic purposes. It is also referred as the science of producing crops and livestock from the natural resources of the earth [2]. Agriculture supports the economic system of India by providing food and raw materials and also it provides employment opportunities to a very large proportion of population.

The primary aim of agriculture in India is to cause the land to produce more abundantly and at the same time, to protect it from descent and misuse. Indian agriculture has progressed a long way from an era of frequent droughts and weakness to food shortages to becoming a significant exporter of agricultural commodities. This has become possible due to persistent efforts at harness the potential of land and water resources for agricultural purposes.

Agriculture is the backbone and important gift for human lives not only in India but also for all over the world. However, majority of the cultivation lands in the globe suffer highly from shortage of irrigation water. Moreover, wireless sensor networks have become the emerging technology in precision agriculture [10]. Modern irrigation systems are built with smart sensor networks for collecting field values for effectively watering the plants [18].

IRRIGATION SYSTEMS

A crop requires certain amount of water at certain fixed intervals throughout its period of time for growth [3]. In agriculture, irrigation helps to grow the crops. Irrigation is the process of artificially supplying crops with water. This technique is especially important in areas that receive little rain or irregular rainfall. Water plays several vital roles in a plant's life. An understanding of the soil water and plant relationship is necessary to understand the various water management principles during various climatic conditions. In the soil [23], there are different types of soil namely sandy, silty, clay, etc. Each type of soil has its own advantages and disadvantages. For example, the sandy soil has high drain capacity.

NEED FOR IRRIGATION

In many areas of agriculture, there is insufficient moisture for the growth of crops even though there is

sufficient rainfall due to the fact that it becomes deficient due to lack of storage capabilities or the rain comes irregularly at unreasonable times. The rainfall is said to be not sufficient when the rainfall is less than 100cm since the irrigation requires at least 100cm of rain [23]. Moreover, irrigation is also needed during non-uniform rainfall where the rainfall is more than sufficient during monsoon season, but fails at other seasons.

Therefore, the irrigation of water is necessary during other seasons where there is a deficiency in rain [7] in order to help the crop growth. Some new high quality hybrid varieties of crops require high amount of the water. Hence, it is necessary to perform the regulation of water flow in order to increase production of the crops as well as the quality. Based on the history of the basin irrigation, it is known that crops such as sugarcane and rice require high amount of water even for normal varieties. In certain situations, where the rainfall is seasonal between June and October and there is no rain during other seasons or the duration of seasonal rainfall vary for 2 months to 6 months depending on the location, it is necessary to provide irrigation to agricultural crops during dry season.

AVAILABILITY OF LAND

Nearly 80% of the 140 million farming families in India hold less than 2 acres of land. Large land holdings enable the farmer to implement modern agricultural techniques and boost productivity. Small land holdings restrict the farmers to use traditional methods of farming and limit productivity. As land holdings are small in India, more people invariably work on the farms in the rural areas and they are coupled with the superseded technology and hence the farm incomes come down. Moreover, lot of the farming lands are converted to residential plots and sold which lead to the decrease of agricultural lands.

WATER QUALITY

The irrigation used for agriculture is based on water availability in the surroundings [3]. Moreover, the quality of the water varies based on the amount of the minerals and dissolved salts present in the water. Though the irrigated water is in minor quantity, it is also needed in healthy crop growth. The minerals found in the irrigation water originate from the solvents present in rocks and soil such as lime, gypsum and other slowly dissolved soil minerals. These minerals are carried along with the water wherever it is used. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These salts are carried with the water to wherever it is used. In the case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop. The suitability of water for irrigation is determined not only by the total amount of salt present but also by the kind of salt [8]. Various soil and cropping problems have been developed since when the total salt content increases, special management practices are required to maintain acceptable crop yields [20]. Water quality or suitability for use is judged on the potential severity of problems that can be expected to develop during long-term use. The problems that result vary both in kind and degree, and are modified by soil, climate and crop, as well as by the skill and knowledge of the water user. As are suit, there is no set limit on water quality. Rather, its suitability for use is determined by the conditions of use which affects the accumulation of the water constituents and which may restrict crop yield.

PRODUCTION TECHNIQUES

The technique of production in India's agriculture is old and outdated. Indian farmers are still using cow-plough method of cultivation on a large-scale. Moreover, the use of chemical fertilizers and high-yielding varieties of seeds has been increased but tractors, and machines are used only on an insignificant scale. However in recent times, because of the introduction of the green revolution in the 1960s, some improvements have taken place. Still the use of modern technology in agriculture is not significant and uniform throughout India.

WIRELESS SENSOR NETWORKS

In the past, farming was a labor-intensive human activity that involved tending plants and animals on an almost individual basis. Modern agriculture, in

contrast, is highly mechanized and involves very large areas per farmer. A sensor network can improve productivity by increasing situational awareness of the state of the pasture and animals.

Ghosh et al. discussed about [13] the essential element of our lively hoods namely the agricultural production which can adversely impact the surrounding environment, especially in regards to water quality. One unique characteristic of agricultural industry is that it provides biological products which are extremely sensitive to both environmental conditions and management practices. It is thus critical that farmers know, in a timely fashion, where variations exist in their fields so as to adjust their practices accordingly. Consequently, any technique that facilitates the stabilization or the increase of agricultural production while mediating the impacts of this activity on the environment is a benefit to society.

According to Michelusi et al., [20] wireless sensor nodes are low power devices equipped with processor, storage, a power supply, a transceiver, and one or more sensors. In some cases it is present with an actuator. Several types of sensors can be attached to wireless sensor nodes, such as chemical, optical, thermal and biological sensors. These wireless sensor devices are small and they are cheaper than the regular sensor devices.

Ojha et al. developed a new wireless sensor network (WSNs) [19] which is an intelligent private network made up of a large number of sensor nodes for intelligent and flexible sensing.

John et al. explained that the wireless sensor devices [14] can automatically organize themselves to form an ad-hoc multi hop network. According to them, ad-hoc sensor networks can be used to perform fault-tolerant sensing for effective data collection from the environment.

ENERGY CONSUMPTION IN WSN

WSN needs longer lifetime to fulfil their indented purposes using the limited energy storage capability sensor nodes. Moreover, the sensor node circuits and protocols have to be energy efficient to reduce the power consumption thereby the lifetime of the WSN can be increased. In order to support the networks with smart devices, advanced computing and networking technologies have enabled the WSNs with intelligence, smart, friendly, context-aware and responsive to human needs.

However, sensor nodes consume their battery energy for the active mode tasks like localization, sensing, actuating, routing, executing the security procedures, sensing the medium, transmitting and receiving the data, etc., The energy consuming activities can be generalized as active mode, sleep mode and idle mode energy consumption. Sensor node's battery energy is consumed even in the idle mode and sleep mode because of the device characteristics [23]. The most commonly used energy storage component is a battery, where in many applications the battery can be neither recharged nor replaced. Hence, the battery backup of the sensor nodes are highly energy constrained. To identify power consumption at each sensor node, it is necessary to identify the factors influencing power consumption. Few factors that affect transceiver power consumption include the type of modulation scheme used, data rate, reception power, transmit power determined by transmission distance, operational duty cycle, header size, packet payload size, symbol rate for a modulation scheme, amplifier power, start-up power, and start-up time.

ROUTING IN WIRELESS SENSOR NETWORK

A crucial goal of the wireless sensor networks is to report events of a predetermined nature or transmit detected information to sink nodes or the base station for further analysis. Each sensor node in the network plays the role of data originator and a router [12]. That is, sensor nodes sense the data and transmit the data to the sink through single hop or multi-hop. Since, a sensor node carries limited and irreplaceable battery sources, the transmission should be energy efficient. The design of routing protocols in WSNs is challenging because of several network constraints with an emphasis on energy efficiency [16].

Most routing algorithms [5] for sensor networks focus on finding energy efficient paths to draw out the lifetime of sensor networks. Accordingly, the power of sensors on efficient paths exhausts rapidly, and therefore sensor networks become incapable of observing events from some parts of their target areas. Consequently, routing algorithms ought to consider energy efficiency, as well as the amount of energy remaining in each sensor, subsequently keeping away from non-functioning sensors because of right on time power exhaustion. Data transmission is the significant source of energy utilisation; it is a serious challenge to design an energy efficient routing scheme for prolonging the network lifetime [15].

WIRELESS SENSOR NETWORKS

Wireless Sensor Networks (WSNs) have their importance in lot of fields including military and agricultural applications in daily life. Tsai et al. [22] analyzed about the lifetime property that is the time taken for the sensor to run out of its energy in WSN and they also discussed about a metaheuristic algorithm and how it deals with the lifetime problem of WSN. The Meta heuristic algorithm proposed by them works in three phases namely transition, evaluation and determination phases which help in the selection of the optimal solution to the problem.

From their discussion it is clear that for applying the Meta heuristic algorithm, it is necessary to understand the various field parameters and to have domain knowledge related to the lifetime problem. WSN is used everywhere mostly for data collection in the recent years. Therefore, unimaginable amount of data is generated every second by sensor nodes and hence data transmission is a concern in WSN [14] because the packet size and frequency determine the energy usage. If the size of the packet is small, it leads to fragmentation and also large packet size causes high power usage and in both cases the power usage is inefficient.

WIRELESS SENSOR NETWORKS IN AGRICULTURE

WSN plays a major role in various fields like military, household industries, agriculture etc., Irrigation is an essential activity in agriculture to sustain crops in order to improve the yield of the crop. There are many works on agricultural data mining and sensors in agriculture which are available in the literature Das et al., [9] De Jong et al., [11], Taylor et al., [24], Anand et al., [4], explained the use of WSN based on their survey on the works related to agriculture and found that the deployment of the sensor nodes at various depths will violate and affect the signal at attenuation. According, the ideal to them depth for the deployment of the nodes has to be identified and determined more accurately. They used hybrid WSN architecture to minimize the human involvement in monitoring the irrigation in agriculture based on sensor data analysis. WSN is an emerging technology in agriculture and it can be adopted innovatively to improve agriculture.[21]

ENERGY EFFICIENT ROUTING IN WSN

Wireless Sensor Network (WSN) is an autonomous device mainly used to monitor the various applications and environments using the sensors. These sensors may be fixed or mobile and are distributed widely to collect the information periodically. Energy efficiency is one of the most important criteria that have to be considered in the design of a wireless sensor network [17]. Continuous monitoring is also a challenge for the design of sensors if the battery power to the network is limited or interrupted. This underscores the requirement that energy should be conserved to the maximum extent in order to make the network active for a longer period of time. In past many researchers proposed energy efficient routing protocols for effective routing in wireless networks.

Routing plays an important role in WSN because it is the main cause for the transfer of data from one node to the other node in the network. Routing of data is also essential for the WSN to communicate in an efficient manner. Zungeru et al. [26] surveyed the routing protocols and compared the classical and swarm routing protocols for WSN. They classified the protocols based on their computational complexity, energy consumption and structure. Finally, they compared and identified the nature of the protocols and listed the drawbacks and advantages in each

protocol. Routing algorithms find various pathways to deliver the information from source to destination. The routing algorithms utilize both the spatial and temporal network information in order to improve the performance of the network. Routing can be carried out with the help of the Internet Protocol (IP), for finding the various routes from the source to destination.

Routing of the information is performed through the various nodes of the WSN. It is carried out in order to minimize the energy consumption and also to increase the performance of the network [25]. Moreover, it is used to route the information in an optimal path. Therefore, many routing protocols are proposed in the literature for the transmission of the information.

CONCLUSION

Water conservation is an important role in agriculture. Therefore, many researchers carried out research for developing new techniques for water conservation. Irrigation is a method of transporting water to crops to maximize the amount of crops produced. Many of the irrigation systems in current use do not use the water in an efficient way. However, they can improve the efficiency by the use of sensors for data collection and analysis. Moreover, wireless sensor networks are used in many applications like agricultural activities, natural disaster management systems, military applications, forest fire detection systems, deep ocean navigations, industrial automations, healthcare systems for elder people, smart home automation applications, etc,.

Conflicts of interest: The authors stated that no conflicts of interest.

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