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A Survey on Ambient Intelligence in Agricultural Technology

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***Abstract*—**Despite the advances made in various new technologies, application of these technologies for agriculture still remains a formidable task, as it involves integration of diverse domains for monitoring the different process involved in agricultural management. Advances in ambient intelligence technology represents one of the most powerful technology for increasing the yield of agricultural crops and to mitigate the impact of water scarcity, climatic change and methods for managing pests, weeds and diseases. This paper proposes a GPS-assisted, machine to machine solutions that combine information collected by multiple sensors for the automated management of paddy crops. To maintain the economic viability of paddy cultivation, the various techniques used in agriculture are discussed and a novel system which uses ambient intelligence technique is proposed in this paper. The ambient intelligence based agricultural system gives a great scope.

***Keywords*—**Ambient Intelligence, Agricultural technology, smart agriculture, precise farming.

I. Introduction

IN today's environment, people are surrounded with networked sensors embedded in all the objects that will respond to their needs. People are expecting an intelligent, embedded and digital environment that is sensitive and responsive to the presence of people. Intelligence in the sense is defined as a sensitive to context, adaptive to learn from the behavior of users and recognizes and expresses the emotion in the desired way. All these are embedded as small, possibly miniaturized devices that merge into the background of people's activities and environments.

Ambient Intelligence is given by enriching an environment with technology. A system which senses features of the users and their environment, then reasons about the accumulated data, and finally selects actions to be taken that will benefit the users in the environment. Sensors are the key that link available computational power with physical applications. Ambient Intelligence algorithms rely on sensory data from the real world. Depending upon the applications various types of sensors are used. Sensors have been designed for position measurement, for detection of chemicals and humidity sensing and to determine readings for light, radiation, temperature, sound, strain, pressure, position, velocity, and direction, and physiological sensing to support monitoring of crops. These sensors are typically quite small and thus can be integrated into almost any AmI application related to agriculture.

In India, the method of cultivation of paddy in a particular region depends largely on factors such as situation of land, type of soils, irrigation facilities and availability of moisture level and distribution of rainfalls. Paddy fields are the typical feature of rice farming in East, South and Southeast Asia. Paddy crops can be built into steep hillsides and adjacent to depressed or steeply sloped features such as rivers or marshes. They can require a great deal of labor and materials to create, and need large quantities of water for irrigation. Oxen and water buffalo, adapted for life in wetlands, are important working animals used extensively in paddy field farming.

The agriculture systems in developing countries are still labor dependent and do not use any crop management, pest/disease control or quality management systems. The traditional irrigation systems in agriculture use uniform water distribution in fields at regular intervals, which is not optimal. Hence, a technology based agricultural monitoring system which decides itself intelligently and performing the action is needed.

II. Problem Statement

Paddy is an irrigated or flooded field where semi aquatic rice is grown. It needs water up to 50 cm deep for at least a month. It needs labor and materials for better cultivation and requires water for irrigation. It is a major source of atmospheric methane (about 50-100 million tones of gas per annum). The main problems in paddy cultivation are maintaining and monitoring soil moisture stress with respect to high or inadequate rainfall, flash floods, water logging or submergence, poor drainage, accumulation of toxic decomposition by the crop, soil iron toxicity. The soil nutrients can be deprived by the continuous usage of traditional varieties and low soil fertility leads to soil erosion, loss of plant nutrients and moisture. The usage of low and imbalanced criteria of fertilizers and heavy infestation of weeds, insects and pests will also affects the growth of paddy plant. Poor attention of the labors over the timely control and poor crop plant population will make the plant to lose their iron and zinc deficiency leads to a state called helminthosporium. Also damage by the birds and rodents to the growing crop will make the field to affect a lot. Hence a technology which uses ambient intelligence which monitors the crop growth, soil moisture, irrigation facility, soil nutrients, usage of fertilizers and pesticides, incurrence of insects and animals is needed.

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III. Related Work

Motion sensors [1] are used to track and find the presence of individuals in a location. But, it can detect the movement but cannot provide information about whom or which event produced the movement whereas RFID technology can monitor the movement of the particular object. But if the RFID reader is positioned in a door frame to monitor the movement of persons between rooms, the person can trigger the reader if they get close to the door, without necessarily moving to the next room. This can be resolved by placing the motion sensors on each side of the door in combination with the RFID reader to distinguish the proximity from room transitions. Another technology for tracking the objects or people is the I-Button [2]. These are devices which are as small as 16mm and contain a computer chip with a real-time clock. It has a unique registration number and the receptor can communicate with a computer. But it needs to be placed over the reader to be effective which is complicated for everyday use.

A. Micro Sensory Intelligent Systems

Micro sensory intelligent systems [3] integrated with a LED technology generates information electronic maps. These maps help to prepare the land for growing crops and gives information about the distribution of nutrients and organic fertilizers applied in soil. Continuous Intelligent Management and Life Cycle Support (CIMLS) technology with intelligent data super protection maintains and controls the life cycle of the agriculture production.

B. LED Technology in Precision Agriculture

Intelligent precision agriculture helps to achieve saving weed and pest killers, fertilizers, energy resources and raising the level and quality of crop yield which in turn increases the efficiency of the agricultural production. The LED technology [4] is intended for taking soil brightness coefficients in the broadband optical spectrum range (1011–1015 Hz) using a set of light emitting and light-sensitive microelements for the illumination of a controlled small piece of soil and for recording the reflected optical signal. This technology comprised with a mobile micro sensory system can analyze a soil state and apply a fertilizer which is required for a particular soil region.

C. Intelligent Farming Equipment

Intelligent farming equipments [5] can automatically decide and perform the field work such as distributing seeds, fertilizers and pesticides efficiently. All the equipments are networked into a cyber-physical production system which in turn maps the process electronically from the farming operation to the harvesting operation. Thus, these systems can increase the efficiency and quality of the agricultural crop.

A tractor moves across a plot of land on an agricultural field. Two tablet PCs are located at the end of the farm. Visitors can start up the automated control of the farm equipment. Six screens are suspended above the model farm. The processes are displayed behind the automation, showing how the new technology manages the functionality of the farming.

D. Climate Smart Technologies [6]

Machines are used to sow rice directly and to inform when to irrigate. Also warning of infestations through phone messages will make the farmers to adapt to climate changes. They receive voice messages to get informed about the weather forecasts. Direct seedling is a technique to sow the seeds directly in the land by machines. This will reduce the labor and water required. Device such as Lazer Levellers is a tractor towed laser controlled devices which allows producing a flat surface in the field to reduce 30 percent less water usage. Tools such as “Happy Seeders” which is attached to the back of the tractors remove the crop residues, blending them into the soil so that soil fertility is increased. But these devices are extremely expensive to implement it.

E. Irrigation Monitoring System

In the irrigation monitoring system [7,8], the information regarding soil moisture, temperature etc are sensed by the Bluetooth wireless transmitters and the time specific decision for irrigation is made according to the information sensed. The irrigation control unit gets the decision and sends the position of the irrigation system using GPS receiver to the base station through real time monitoring. Base station in turn sends control signals to the irrigation control station to operate the device for water usage. Also distributed irrigation system [9], sensor based irrigation system [10] and automated field-specific irrigation system [11] are also provided good irrigation control. Yet, all these do not consider the pollution of water.

F. Using Low Resolution Camera

Sensor network based field management [12] uses solar powered moisture nodes and low resolution camera. These self contained, self-powered low resolution camera nodes send information about the height, coverage and greenness of the field grass through sensor networks to the base station. Then it allocates time for these camera nodes to send images. The camera nodes can also be used to observe the position of cattle and its behavior.

G. Swath Control and Variable Rate Technology

Swath Control [14] is a one which operates the equipment in the field to work correctly so that it use less inputs like seed, fertilizer, herbicides, etc. If the size and shapes of fields are irregular it is easy to overlap to some extent in every application. GPS mapping in the equipment already knows where it has been. Swath control shuts off sections of the applicator as it enters the overlap area, saving the farmer from applying twice the inputs on the same piece of ground.

Variable Rate Technology [14] works on the basis of production history and soil tests. According to that a farmer can build a prescription GPS map for an input. By knowing what areas of a field are most and least productive the application rate of an input like fertilizer can be tailored to increase or decrease automatically at the appropriate time.

Instead of applying a set rate of fertilizer over the entire field (many times a high rate to help those low producing areas) an operator can now apply a rate most effective for a particular section of ground.

H.Other Technologies

Autopilot [13] is a new system that automatically steers tractors automatically within some inches for row-crop applications. This technology results in increased productivity for the farmer through more efficient use of tractors and extended working hours. This autopilot system easily connects to the tractor's power steering hydraulic system to automatically steer it in straight rows - pass after pass. A field computer inside the cab allows the operator to select field patterns and display operating parameters. A lightbar is used to guide the tractor on path at the beginning of a row. Once on a row, the driver engages the Autopilot system to perform and oversee field operations. This system saves time and money. It reduces driver fatigue, eliminates guess rows and allows around-the-clock operations. Most importantly, the system increases efficiency to lower the cost per acre. The consistency of straight rows makes subsequent events in the field such as planting, cultivating and harvesting more efficient because there is no longer the need to modify the machine set up when rows are evenly spaced.

Discovery channel in 2003, reported an application of a wireless sensor network in a vineyard in BC, Canada. 65 motes were installed in a 1 acre land to remotely report temperature, moisture and sun light intensity to a central PC every 5 minutes. The owner could easily monitor each area of the vineyard in real time to avoid frost, manage irrigation, determine fertilizer applications and arrange harvest schedule. A solar powered wireless sensor network was reported to provide weather information in fields.

Pixel Intelligence Mapping is a measure from satellites, which shows how much carbon or water is needed. It is the ability to capture and read the carbon dioxide output, water evaporation and temperature of the leaves using a satellite as it passes overhead. The data can be interpreted and accessed by the farmer. Within a year, this data will be available in the field direct to smart phones using Esri app. Scientific information combining with the farmers' local knowledge is used to increase crop yields and improve water efficiency.

I. Technology in PLANTS Project [15]

In PLANTS project, an infrared camera is used to scan the field area and it detects when the plants are getting warm. Sensors are used to detect the chlorophyll fluorescence which in turn gives the information about the energy absorbing rate in the plant. It is helpful to identify the status of photosynthesis in plants so that plants health is identified and monitored. The data which is sensed is communicated through a wireless transmitter and the overall management is done by ePlantOS. In total this project helps to control the consumption of water, nutrients and pesticides.

J. Crop Productivity

Crop productivity is reduced by certain diseases in the rice plant. The occurrence and harshness of the diseases cannot be predicted so easily. An LP based color texture analysis [16] in rice leaves is used for identifying the leaf blast diseases which is affecting the rice plant. These diseases will cause the mineral deficiency in the rice plant. To find the mineral which is deficient an MLP classifier for color texture analysis [17] in mineral deficient leaves is used. Also the crop productivity is affected by the occurrence of unwanted weeds in the field. Yang et al described site-specific information [18] is used to find out the weeds in real time using image processing and fuzzy logic.

In machine dependent agriculture, an automated harvesting method which used video camera and GPS for different horticultural crops is introduced by [19]. Machine vision identification [20] is used for differentiating weeds from tomato seedlings is also there. Image processing methods may apply to determine the ripeness of the crop by comparing the hyper-spectral images with standard RGB images of the crop [21].

IV. Conclusion

Majority of the difficulties in monitoring a field crop towards its growth and harvesting can be solved by using ambient intelligence technology. Power management can also be done by using solar panels in agriculture fields to effectively recharge the battery and sensors. Communication cost between the sensor nodes and the central server is also reduced by using efficient wireless technology such as Bluetooth, WLAN, etc. Hence with the effective use of ambient technology we can able to monitor everything in the agriculture in a more efficient way which in turn increases the overall productivity with less input and effort in a more hygiene way.

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