

Creating a Smart Agricultural Environment using Ambient Intelligent Technique

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Abstract: *Almost in all the fields, the world is moving towards digitally. Automation, smart environments and precision activities are still spread its wings to make the human life easier. Ambient Intelligence (AmI) aims to create a smart electronic environment which is more responsive to the presence and interaction of the people. Using this intelligent technique, a novel approach for the cultivation of paddy is introduced in this paper. Developing a smart environment for the paddy cultivation helps the farmer a lot to increase the productivity. Technology involved in AmI, its corresponding architecture, prototype are discussed in this paper.*

Index Terms: *Ambient Intelligence, Smart Environment, Automation, Smart Farming Practice, Intelligent Computing.*

I. INTRODUCTION

Smart environments requires a high degree of automation which is more adaptable to the changing environments and communicate it to humans in a more user friendly way. It focuses on creating a physical world which is loaded with sensors, actuators, mechanical devices and user interfaces, embedded in daily activities and connected seamlessly towards a smart intelligent network. Ambient Intelligent comprises with the evaluation of ubiquitous computing, ubiquitous communications along with the personalized user interface. Computation can be done at any time, any place and whatever situation of activities may occur. The system is always available to the inhabitant or user to provide the seamlessly endless services which satisfies the desire of them. A very good real time example to understand this will be the emerging techniques in creating a smart home. The home will be continuously monitored with the help of available sensors embedded in various smart devices. Based on the sensor readings, the system will constantly make small adjustments and customize its behavior according to the surrounding context. For example, motion sensors will identify the presence of person in a particular room and initiate the command for providing the lighting support in the room. Based on the value about the amount of daylight coming into a room, system will initiate the command for adjusting the window blinds in particular room. One of the main advantage of this smart environment is adjustable control over devices remotely and giving permission to the devices to communicate with each other and act accordingly. It provides a connected environment in a particular context.

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It offers a smart service with the help of smart devices and sensors without the need for human intervention. In the mean time, all the information and activities are communicated with the inhabitant through an intelligent user interface. Hence, it will give a pleasure environment for the inhabitant that everything is under their control without the necessity of their presence. Proposed idea in this paper is to create this type of smart environment in the cultivation of paddy using Ambient Intelligent (AmI) Technique. The devices and sensors in the paddy field area can give details about the environment and it takes decision intelligently to act accordingly. With the help of improvement in the wireless sensor network and the computing technologies using IoT, things are getting easier to create such environment. Activation of one device or event will trigger other sequence of event to give complete control over the environment. Paddy is a semi-aquatic crop which needs sufficient water and air to give good productivity. Linking the system, devices and sensors in order to do everyday agricultural tasks in the cultivation is the main task. This will require the highly deep knowledge about the paddy agricultural domain, machine learning, decision making, computing techniques, sensor networks, etc. Developing this system will reduce the man power requirement and reduce the impact of using fertilizer and pesticides. The proposed system will provide a good crop health monitoring throughout its cultivating period. The paper is organized as follows: Section II describe the related works using AmI techniques. Section III describes the proposed agri system model and architecture. Section IV provides the layout and prototype of the proposed technique. Section V discusses about concluding part and future works.

II. RELATED WORK

Many researchers focused on developing agricultural activities in a smart manner. People are trying to include a sensing mechanism to sense the environmental factor and communicate it with the central system to produce the desired output [7]. Using wireless sensor technology, micro climatic parameters are closely monitored to reduce the human intervention as much possible. This will also reduce the usage of pesticides and fertilizers [8]. In order to provide an automatic irrigation using less time, land water level is given as an input to a fuzzy logic. The system will evaluate and manage the load shedding problem with a minimum error [9]. Weed Infestation Rate is calculated and based on that real time decisions are taken to identify the occurrence of weed [10].



III. PADDY FIELD ENVIRONMENT

The field environment is characterized as the sampling area in which the paddy sampling is planted. The field should be fallowed, ploughed and leveled to be ready for the forthcoming cultivation. The crop should be monitored for its growth and health conditions. Automation is done by having a collection of networks assigned separately for monitoring different agricultural tasks. Monitoring is done by combining the activity of sensors and actuators and notifies everything to the farmer (inhabitant). Supporting devices such as sensors, sprinklers, actuators like tractors, weed rotator, etc. is established and sometimes network connected. Establishing connectivity seems to be very easy nowadays as the cost of networking tends to be very low. One of the more comfortable and cheaper networking standards is ZigBee module which comes under IEEE 802.15.4 standard and works even with low power digital radios. It can cover the area up to 10 – 100 meters LOS which will be suitable for communicating in the paddy field area. The overall system must able to maintain the availability of data at any situation in order to decide over a particular issue. Suppose if the system identifies a significant color change in a particular plant in an area, it should decide whether it is a normal change or it will be caused because of the dryness in that area or it should be due to the occurrence of any disease in that area. And based on the decision, it should give command to the water sprinkler or the fertilizer sprinkler and notifies it to the farmer concern. This will be done efficiently if the data is available. Sending information and alerts to the farmers is done by using his mobile phones Short Message Service (SMS) or in the extreme case, in a mobile app in a smart phone. Data needs to be collected and communicated without any connectivity issues. And the ability to control over the device remotely makes the farmer little more comfortable. Device can deliver the message and updates its status on demand or in response to a particular situation. Suppose if there is damage in the sprinkler system and the water is wasted, the system immediately notifies it to the farmer and waiting for his response to take corresponding action. If the response is not coming for a stipulated time, then it will decide accordingly either to switch off the particular pipe line motors or to change the connection.

IV. AN EXAMPLE SCENARIO

Say Mr. X is the inhabitant (farmer) who is cultivating paddy in his 1 acre of land. Initially he has to plough the land and sow the paddy seedling or offspring. For that he requires man power to plant the paddy offspring into the land. While planting the offspring, the field has to be immersed with water. Laborers are randomly plant the sampling into the desired place. Every day Mr. X will go to his land, check for the status of the plant and do the necessary things. He will check for the irrigation condition, water level etc. He used to fill the land with water daily or once in two days according to the water requirement he analyzed, though the plant may not need the water. He sprays fertilizer and pesticide throughout the field, where it will lead to the over usage of fertilizers in

the plant. Then he has to check for the occurrence of any disease in the plant and has to spray pesticide. Most of the cases, the fertilizers and pesticides are spray throughout the field, unnecessarily. And at the time of harvesting, he again needs man power to harvest the entire field. This type of manual cultivation requires a lot of time for continuous monitoring of the cultivation. And it also results in more input wastage such as water, fertilizer and pesticides. Again, labor problem and the financial condition of the farmer is also questionable. Rather than that, AmI insisted automated cultivation will reduce most of the problem rendering there. Consider the following context: Mr. X has a AmI integrated smart phone with him. And his land is embedded with sensors and actuators which is also network-connected. The system identifies the field area and plot the area into grid arrangement. The AmI system commands the transplanting machine to transfer the paddy offspring in the grid point. This mechanism is work under the concept of System of Rice Intensification (SRI) where sufficient spacing between the paddy sampling leads to get more air and more space for the growth of paddy tillage which in turn leads to the increase in productivity. Water level sensor and the humidity sensor sense the value of the water required by the plant in a particular area and give commands to the sprinkler system using area based information. Soil pH sensor sense the acidic nature of the soil and make sure that will not affect the health growth of the plant. Camera present in the field, capture images and notifies if there occurs any change in the color of the crop in a particular region. The system will analyze the change and decide whether the damage is occurred due to any pest. Based on that, the system will give commands to the fertilizer sprinkler to spray the fertilizer needed in the particular area using Variable Rate Technology (VRT). The significance of VRT is to prevent the sprinkler from spraying the fertilizer in an already sprayed area. All these activities will be done on a daily basis and the corresponding activities will be notified to the farmer when and where it needed.

V. PROPOSED ARCHITECTURE

The advantage of this system is the reduction in the man power and input requirements for a farmer. It mainly concerns about the comfort of the farmer and doing everything in a secure manner. This system will act as a personal assistant who takes care of all the cultivating activities in the field area and do the needful in critical times. The proposed AmI architecture for paddy automation is shown in figure 1. It comprises of four layers; physical layer, information layer, communication layer and decision layer. The required data collection is done by sensors in physical layer and the processed data is given as a command to initiate the actuators. The sensors are embedded everywhere in the paddy field area. And the actuators are readily available and connected in the field area to act according to the decision. The information layer stores the sensed data in a repository

and updates the sequence if there is any modification in the daily sequence sensed. The collected data is processed and communicated in the communication layer.

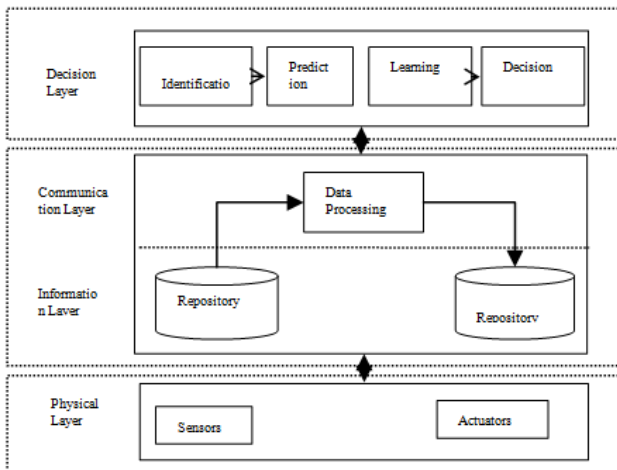


Figure 1. Proposed architecture

The processing is explained in the next section. In the decision layer, sequence identification is done from the processed data. Based on the sequence identifies, next possible event is predicted and it will be learned and updated in the repository. Based on the predicted event, command will be given to the decision process which in turn sends it to the actuators.

VI. MODEL DESCRIPTION

The proposed model has 3 distinct phases in it. They are: data collection phase, data processing phase and intelligent learning phase.

A. Data Collection Phase

Creating a smart environment in agricultural task is really a complex one. It has unique requirements, architecture, systems and goals. Working knowledge of the paddy field is really important. Understanding the farmer's needs and the activities performed in the field area will help more while designing the system. For achieving this, field study is done throughout TamilNadu. Field Study is very valuable to understand the user needs and requirements in the particular domain. Questions related to the current activities and technologies followed by the farmers are asked through questionnaire. The data collected is qualitative that will explain why and what the farmers are doing till now and what are all the problems they faced during the manual cultivation. Analyzing the data obtained from the questionnaire, it is noted that only 20% of the people are using machine transplantation. Most of the people prefer canal irrigation as the paddy crop needs more water. At the end, optimum temperature, moisture value and humidity value for the good growth of paddy is identified through this. For implementation purpose, DHT1 series moisture and humidity sensors, soil pH sensors and the required sprinklers are incorporated into the field area for data collection.

B. Data Processing Phase

For creating a smart environment in paddy cultivation,

there are five parameters to be monitored. They are irrigation, soil health, pest management, disease management and weed management. If the system can able to successfully monitor all these parameters, then automation is also possible. The simple work flow diagram is shown in figure 2.

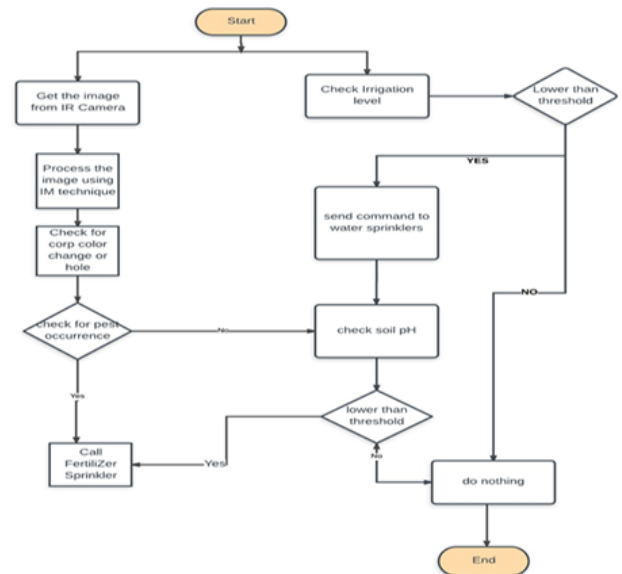


Figure 2. Work Flow of the System

Data is processed on a sequential manner. Details about the irrigation, nutrition value, occurrence of pest and diseases are monitored simultaneously. If it is occurred then the corresponding actions are performed. Details of all the parameters and its description are given in table 1.

1) Irrigation:

For every 4 hours, soil moisture sensors are checking the moisture value and air humidity value. If it is less than threshold, provided the water level value is also lower, and then alert will be sent to the farmer. Based on his response, the system commands the sprinkler to water the particular area. The sprinkler is also run for a specific time which is monitored by a timer.

2) Soil Health:

There will be a connection between the soil pH value and the corresponding macro and micro nutrients in the soil. If the pH value is less than the threshold value (say 5 -6.5), then there will be a deficiency of a particular nutrient in that area. The system immediately checks for the occurrence of any diseases because of the nutrient deficiency. Some of the diseases which occur due to nutrition deficiency are sheath blight, red stripe, leaf scald, false smut, etc. If so, command will be given to the fertilizer sprinkler using Variable Rate Technology (VRT).

3) Pest & Disease Management:

Images are captured once in 3 days to check for the occurrence of any pest or disease in a particular area. Usually paddy crops are affected by pest or disease in patches. i.e if a

damage is found in one plant, then the possibility of the surrounding plant damage is more. These images are processed and converted into grayscale value. And using segmentation, filtering and color identification, and the respective damage can be identified. Some of the pest damages the paddy crops are leaf hopper, mealy bug, army worm, caterpillar, gall midge and stem borer. The disease occurred by these pests are usually the color change in the leaf, reduction in the crop height, false grain, cutting of the edges, leaf rolling, hole in the leaf, etc.

C. Intelligent Learning Phase

Learning is happened as the system continuously monitored the environment. The system registers all the device events carefully and identifies some sequence among the events. From the sequence, episodes which happen continuously in an ordered manner are identified. And from the identifying sequences, the most predictable upcoming event is identified and the corresponding action command is given to the actuators through decision making process. If the particular decision is interrupted by some other actions, then it is noted as a new sequence and that is stored in the updated repository. The more the system learns and updates, the more the possibility of successful automation. And this will require some time to learn by observe the event happens.

1) Episode Identification

Episodes are defined as a set of events which is observed to happen repeatedly over a given period. They may be in an ordered manner or in an unordered manner.

Let D be the set of all device events (where the device events are Water_Sprinkler_i_ON, Water_Sprinkler_i_OFF, Fertilizer_Sprinkler_i_ON, Fertilizer_Sprinkler_i_OFF, Rotator_ON, Rotator_OFF, Cam_i_On, Cam_i_OFF where i ranges from 1 to n)

Event Occurrence E can be defined as the pair (e,t) i.e event happen at a particular time.

For eg: E₁=(Water_Sprinkler1_ON, 6.00 am),
E₂=(Water_Sprinkler1_OFF, 6.15 am),
E₃=(Cam_ON, 8.00 am)

Event Sequence S_i can be defined as an ordered sequence of event occurrences E where i ranges from 1 to n

S₁ = {E₁, E₂}, S₂={E₁, E₂, E₃}

From the event sequences, episodes are identified which can be defined as set of event occurrences and candidate item set. Candidate item set can be found as set of events and episodes where each event has an occurrence in each episode.

1) Predicting next event

After identifying the episodes, the corresponding sequence of input is parsed into several sub phrases, followed by the calculation of context statistics for each and every sub phrases. Then the sub phrases are assigned some token based on the first occurrence of events. Then calculating the probability of each state and assigning the predicted output to the higher probability event.

2) Decision making

Based on the predicted event, alert is given to the farmers and commands are given to the actuators according to his response.

Table 1. Parameter Description

Names	Irrigation	Soil	Pest	Disease	Weed
Sensors Used	DHT1 Sensors, Float Switch Water Level Water Sprinklers,	pH Sensor, IR Camera	IR Camera	IR Camera	IR Camera
Actuators Used	Water Flow Outlet, Water Source	Fertilizer Sprinkler	Sprinklers	Sprinklers	Rotators
Activity Performed	Command signal to water sprinklers	Call Irrigation Module/ Command signal to Fertilizer Sprinklers	Call Disease Module/ Check for Irrigation Level / Command signal to Pesticide Sprinkler	Call Pest Module/ Check for Irrigation / Check for Soil Health	Command signal to Weed Rotators
Alert to Farmers	Yes	If needed	Yes	Yes	If needed

VII. PROTOTYPE LAYOUT

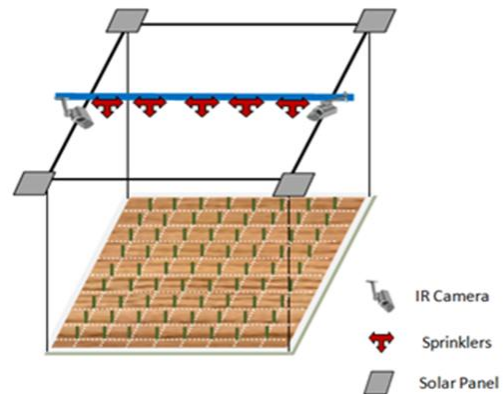


Figure 4. Sample Layout Of The Paddy Field With The Proposed Idea

The sample layout of the paddy field is shown in figure 4. For simplicity, one acre square field area is chosen. The entire field area is divided into grid area with the grid spacing of 20 cm. Hence for one acre area of land, we got approximately 318*318 square grids i.e. 256 grid points. The paddy off springs is planted in the grid points. A steel rod crane system is attached with the field which has front and back movement based on the command given. Sprinklers are attached with this crane system to help with the irrigation and fertilizer module. All the energy required by the sensors and the crane system movement is provided by the solar panel attached at the end. Sensors are embedded throughout the field to monitor the environmental parameters such as humidity, moisture, water level, etc. Two infrared cameras are attached with the crane system and the image taken by the cameras are analyzed for the detection of pest and disease occurred.



VIII. RESULT DISCUSSION

Maintaining a smart environment in a field area faces unique challenges every day. As the WSN technology join hands with IoE, it is possible to create an effective solution for the system. The main challenge faced from the sensor environment is its deployment. Since the field area is an open environment, a proper infrastructure is needed for the deployment. The sensor should be protected with a water-proof insulation and should be placed rigidly from the environmental issues. The experimental setup was tested for two cultivation period and the system is allowed to modify any mistakes throughout the period. The crop variety chosen is red samba rice which has 3 months of cultivation period. First round of cultivation is done by the month of April – June. Two trusted farmers were used to monitor the systematic activities. Around 6th week of cultivation, Rice caseworm is identified by the system and it was confirmed by the farmers. Later week, Mole Cricket and Root Aphids were identified in the field by the system. Mole Cricket can eat the roots and affect the growth of the plant. Scarcity of water in the fields can incur a favorable condition for the growth of the pest. Hence, the system suggests maintaining water level in the field area. For each suggestions and findings, the system gets approved from the farmers in order to make it to learn new context finely. Similarly, Root Aphids can suck the plant to remove the fluid content in the plant. This will create yellowing in leaves and thereby creating stunting effect. This type of warning about the presence of pest and disease before its occurrence helps the farmers to be in their pace. Crop color and the plant height are continuously monitored, thereby reducing the pest or disease occurrence.



Figure 5a: Offsprings Are Planted With 25 Cm Distance



Figure 5b: Paddy Crop Around 2nd Week Of Plantation



Figure 5c: Crop Around 3rd Week With More Chlorophyll



Figure 5d: Visible Results In Increased Leaf Area Index
Second round of cultivation is done by the month of September – November. Same cultivation steps are repeated with same type of red samba rice. The system performs well and manages to give all the required actions to perform automatically. Figure 5a-5d shows the growth of paddy plant in the field area throughout the cultivation period.



Figure 6: Crop Around 90th Day Ready For Harvesting

Visible increased in the height of the crop when compared to the traditional cultivation method is seen. Increase in chlorophyll content, increase in crop height in every stages, increase in productivity with minimal amount of input seeds are the notable results achieved by the proposed system. After the harvesting, the quality of the rice grain is also checked and it shows 70% of quality grains. The system achieves a very good automating environment with minimal seed input and man power input and also equivalent productivity compared with traditional cultivation. First cultivation takes place in summer where the deployment of system, sensors and actuators are not affected by the environment. Second cultivation phase occurs in winter in which the climatic conditions are disturbing the deployment. Yet, proper insulation is provided to the components so that the performance is achieved without any inhibition. Feedback is taken from the associated farmers about the system performance and the convenience. They are highly satisfied about the performance of the system as if they have a highly knowledgeable assistant in the field area.

IX. CONCLUSION

To reduce the human burden towards the cultivation of paddy in the agriculture field, automation is a needed one. This AmI technology will help in achieving this contest by continuously monitoring the environment and acts like an assistant for the farmer in achieving the target cultivation. This also ensures the quality of the crop production by carefully monitoring and detecting the occurrence of pest and disease. Through this, the occurrence of weed is fully avoided. It also helps in reducing the input parameters such as seed, fertilizers and water. 1

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