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Green house based on IoT and AI for societal benefit

Meghal Nargotra
Department of Technology
Savitribai Phule Pune University
Pune, India
meghalnargotra@gmail.com*

Mandar J Khurjekar
Department of Technology
Savitribai Phule Pune University
Pune, India
Mandarjk@gmail.com

***Abstract*—The paper "Greenhouse based on IoT and AI for societal benefit" using a native microcontroller (LPC2138), environment monitoring sensors, communication module (ESP8266), along with a server design (which takes into account the real time weather forecast, and data analysis on the data gathered by sensors for irrigation decision) is focused on achieving automation, IoT deployment level -3, wrong weather forecast counter-action in real time with automation and intelligent control for water utilisation and optimization which will result in a uniform yield. The system described optimizes water utilisation on the basis of plant's water need instead of cultivator's assumptions by working on static data such as plant and soil type and environment dynamic data gathered from sensors. The data has been tested for algorithms such as Naïve Bayes, C4.5 and SMO (svm). A web page has been created which can be used for monitoring the data of green house.**

Keywords—server; IoT; C4.5; weather forecast; automation; irrigation; plant need(key words)

I. INTRODUCTION

The system aims to completely automate the greenhouse system. Though automation is present in this sector, but the decision making part remains limited to controllers. This paper describes the system to build a scaled down prototype representation to achieve automation in the system by sensing parameters using sensors such as temperature, humidity, soil moisture and rain. The data fetched is going to be sent to server where proper decision is taken for automation. Since the aim is to reduce as much human involvement as possible this system based on internet of things needs to be made intelligent and intuitive. This is achieved by taking into consideration the major factors that may affect irrigation patterns and in long term help in saving water. The irrigation decision is based on requirement of plant rather than the external factors such as soil moisture alone. This is achieved by working on the attributes that may affect the plant's need and forming a decision using prediction algorithms. The system is also going to take into account the fact that the weather forecast available has a chance of going wrong. So, to counteract that, a proper flow of logic is built which may completely eliminate the chance of wastage of water and provide a optimised irrigation system.

II. LITERATURE SURVEY

Preliminary work in this field has been carried out shows that automation pertains to the controller made decisions only. Y. Shekhar [1] and co researchers have used M2M communication. M. Roopaei's [5] paper mentions using image processing techniques and assessing water stressed areas for irrigation. I. Mat, M. R. M. Kassim [2] and co researcher have carried out experimental research which proves that closed loop system are much efficient for irrigation than time driven systems. Decision tree type ID3 has been used for assessing water management in N. Tamboli's [4] paper. Paper titled "Towards the definition of internet of things (IoT)" gives an all inclusive definition of IoT.

F .P Jooste and co researchers have implemented irrigation system with much of the focus on energy efficiency [3].

III. WORKING OF SYSTEM

A. System Architecture

The system is divided into 2 platforms - Green House unit and server unit. The scaled down version of the automated green house unit consists of a native microcontroller which is LPC2138. A controlled environment cultivation requires continuous track of important factors which affect the crop's quality. Hence sensors such as LM-35(temperature), YL-69(soil moisture), SY-HS 230(humidity) and raindrop sensor are deployed. Wifi module ESP8266 is used. It off loads WiFi related tasks to the module, allowing the microcontroller code to be very light-weighted. Use of ESP8266 eliminates the need of another module at the user end because the end user can access the web page through phone or computer system which have in built wifi connectivity. The further decision making part which is used to provide automation (functioning fan for cooling, retractable roof and water pump for irrigation) is delegated to the server backend. A rain drop sensor module which functions as a water saving device, signals the shield of the green house to open using stepper motor when rain fall occurs. The whole unit's block diagram is shown in Figure 1. The system flow is presented in figure2.

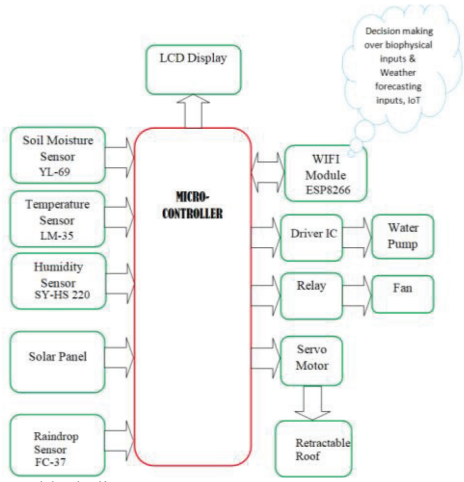

Fig. 1. System block diagram

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B. 3- Step Irrigation process

The functioning of pump [9] for watering purpose is optimised in 3 steps. The first factor which is essential is soil moisture. If the soil moisture present is in sufficient amount, the pump remains off, otherwise, the decision is directed to the plant need stage. The plant need stage, is nothing but a predictive machine learning algorithm. This algorithm takes into account both static as well as dynamic parameters to give a decision whether the plant requires water or not. The algorithm is fed with parameters such as type of plant, age of plant, and type of soil along with the sensed parameters such as temperature, soil moisture and humidity. This stage is essential because in most of the papers surveyed, it has been observed that the plant requirement is not considered anywhere for irrigation. Most of the systems have watering systems which are either time driven or manual. Such systems are therefore just based on assumptions, whereas the foremost decision to irrigate should depend on the need of plant. If this stage suggests, that water is required by the plant, the weather forecast is checked.

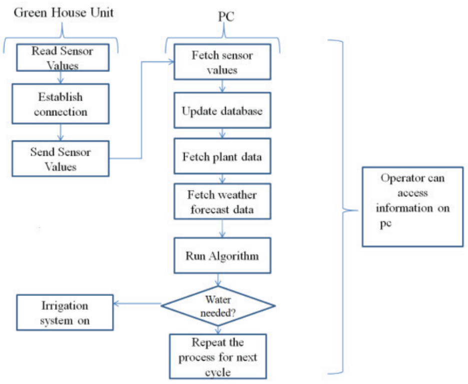

Fig. 2. System flow

For the weather forecast, Yahoo library weather API is integrated to take input of real time weather forecast. If the forecast suggests a rainy weather, the native controller is directed to keep the water pump off. In such case if the forecast is true the roof is opened as the rain sensor detects the rain. If the weather forecast is false, in such a case the pump is directed to remain off. This conditions needs to be counter acted because if the forecast goes false a number of times the plant may wilt because of water deprivation. In this system the threshold for false weather forecast is set to 50. If this limit is crossed the pump is directed to switch on. The important point to note is , since the soil moisture is being monitored continuously incase the forecast is corrected in time by the responsible authority, the pump will automatically be directed to switch on.

The cases when weather forecast for rain may go wrong leads to 4 conditions as follows:

1. If prediction is rain-The native controller is automatically directed through server to keep the water pump switched off.

(a) Rain happens -The shield is opened after receiving input from the rain drop sensor via controller.

(b) Rain does not happen- The pump was not switched on because the weather forecast was rain, so this is checked for a few cycles. If the false weather forecast occurs for a set limit, then the pump is directed to switch on.

2. If prediction is no rain -The water pump is switched on.

(a) Rain does not happen -The water pump was already directed to switch on.

(b) Rain happens -The rain sensor is checked, it detects rain, water pump is switched off, the rain water is let in automatically as the shield will now open. The pump working is controlled from the server side. The functioning is summarised in figure 3.

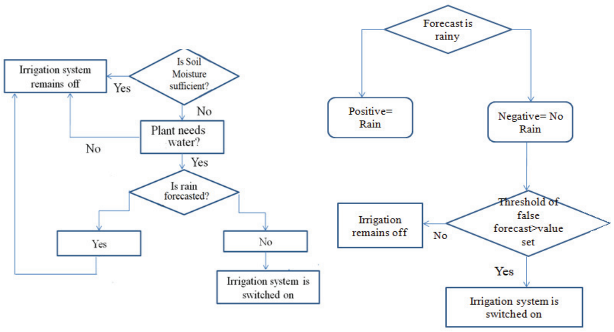

Fig. 3. Three step irrigation

C. Connectivity Establishment

1) Network Testing

The local intranet was created for testing and developing communication between the green house unit and the local server (pc) using socket test 3.0.0. The ESP8266 was used for giving the green house unit native controller WiFi connectivity.The network was provided by mobile phone. The WiFi availability at both the ends that is the unit side and the pc provided ease for testing.

2) Database connectivity and Web development

Mysql 5.5.29 was used for database management. The sensors values were updated via the connectivity provided by HeidiSQL 3.2 administration tool. The web server was designed on the local system using Tomcat Server 8.0.3 (an open-source Java Servlet Container). The server implemented provided services such as new user registration, storage of parameters, updation of parameters, deletion of parameters and validation of parameters. The front end development was implemented as a combination of HTML and CSS styling. The operator could enter the username and password to monitor the conditions of the green house in the developed web page.

D. Predictive Analysis

1) Data collection for prediction purpose

The attribute file was created using data from FAO (UN) for some specific plants and was used for testing the 3 algorithms, decision trees, smo and Naive Bayes using the WEKA package. A random training set was prepared with the values for temperature, soil moisture and humidity randomly added after going through the optimum climate requirements for the selected plant options obtain from the FAO crop information portal.

2) Model Training, Testing and Evaluation

Naive Bayes, C4.5 and SMO (John Platt's sequential minimal optimization algorithm for training a support vector classifier) were fed with training data. The model was tested with real time instances of sensor values. The decision tree C4.5 was evaluated for the taining set in the WEKA data

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mining tool, J48 which is an open source Java implementation of the C4.5 algorithm. The Naive Bayes was tested with the help of weka.classifer package. SMO was tested with the help of weka classifer function smo package. Since there was no dedicated test data set, which is why our objective is to predict the same, the classifers were trained, evaluated and compared [7].

The algorithms were compared based on metrics obtained for each prediction algorithm as in table I and II.

TABLE I. COMPARISON OF METRICS FOR ALL THE THREE ALGORITHMS

Algorithm	Correct%	Kappa	TP rate	FP rate	Precision
Naïve Bayes	69.73%	0.3819	0.697	0.317	0.696
J48	82.89%	0.6506	0.829	0.181	0.829
SMO	68.42%	0.3481	0.684	0.341	0.682

TABLE II. COMPARISON OF METRICS FOR ALL THE THREE ALGORITHMS

Algorithm	Recall	F measure	ROC Area
Naïve Bayes	0.697	0.697	0.783
J48	0.829	0.829	0.854
SMO	0.684	0.681	0.672

IV. RESULTS

The purpose of this work was to create a scaled down automated green house unit under the umbrella of IoT. The system is shown in figure 4.

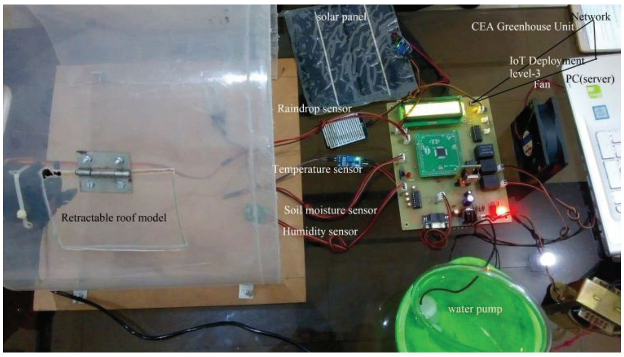

Fig. 4. Green House based on IoT and AI.

Initial testing was carried out in the simulated environment in the Proteues Design Suite which was also compared with controlled environment simulation by modelling sensors in hardware. The crucial advantage of controlled environment automation (CEA) in Green house using IoT was that, it was able to store both the real time data and gave an option to monitor these parameters from anywhere by accessing the web (Figure 5). The greenhouse environment condition can also be viewed in the graphical form for easy fault detection of sensors (Figure6).

After exploiting the crop data obtained from the Food and Agriculture Organization by selecting the attributes which might play a vital role in achieving the objective of predicting the need of water by the crop, a training data set was constructed. Further, the model was designed such that the real time dynamic attribute features were retrieved and appened with the static plant data. This instance was used as a test input for which the output was predicted continuously. The training data was tested with various machine learning algorithms. It was found that decision tree C4.5 is best for this application because it works well with both nominal and numeric attributes, and hence eliminates any need for make attributes uniform.

Fig. 5. Web page for monitoring sensor values

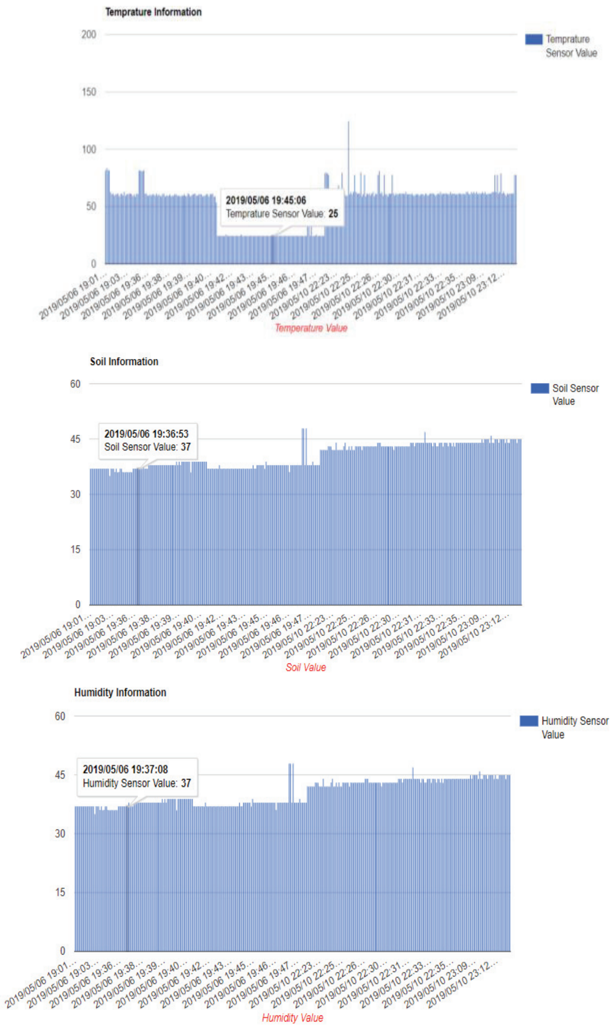

Fig. 6. Graphical representation of Green House temperature, soil moisture and humidity on web page.

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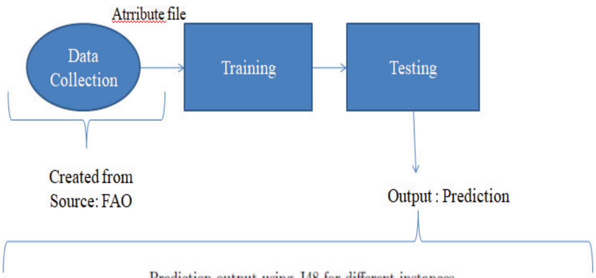
The water utilisation was assessed with different combinations of datasets (Figure 7). values and speed was a crucial factor for choosing the algorithm. Even though all the models gave output in the same time, but few research papers show that decision trees perform well as far as readiness of data is concerned. Another feature which saves data preparation time is that missing values do not prevent splitting the data for building trees. It can be used in case where there are non linear relationships between parameters as they do not affect tree performance.



Prediction output using J48 for different instances

Crop	Age	Soil Type	Temperature	Humidity	Soil Moisture	Water Need Prediction
gazania	2	normal	45	56	33	Yes
tomatoes	3	black	45	56	33	No
soyabeans	3	normal	45	56	33	Yes
pepper	2	red	45	56	60	No
pepper	2	red	45	30	20	Yes
peas	2	normal	45	30	20	Yes
pepper	2	red	45	30	20	Yes

Fig. 7. Plant water need prediction

It is also know that the attributes which play the decisive role in prediction of need of water are interdependent on each other, hence it was realised that while choosing an algorithm the dependency factor had to be considered. Since the all the plant/crop attributes and the surrounding attributes are interdependent, it seemed as good option to eliminate Naive Bayes as an option for prediction of water as it inherently assumes independence of inputs. Given that the metrics, obtained are for a limited set of data, the results for larger data set might differ slightly, therefore it may be that SMO, may serve as a better classifer when there is larger dataset, speed and memory requirement are major factors influencing the selection of algorithm. It is observed that on a unbalanced training data set SMO performed better than J48 when metrics are concerned ,but in such a case the accuracy can be misleading and hence the metrics obtained for the analysis performed over nearly balanced data set were considered for comparison. The metric comparison show that J48 performs well as compared to other algorithms. It has been observed that for some test instances, the prediction given by one of the algorithm doesn't match the other, but this can be attributed to the fact that all the three models for predictive classiffcation have different inherent structures and not all of them are suitable for one particular application.

V. FUTURE WORK

Such as system can be extrapolated for large farms by increasing the number of nodes and adding a coordinator system which can make the system to shift to next level of IoT deployment. Prediction of water can be validated for larger dataset. Reinforcement learning is utilized to find the best possible route it should take in a real situation. More functionality such as misting can be added for controlling humidity in the environment which plays an important role in plant's germination, growth and reproduction. The whole system can be shifted to work on solar power in future. Factors such as ph and nutrients can also be sensed and monitored for more productive and uniform yield.

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