Automatic Irrigation System Based On Soil Texture With Farm Security

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***Abstract*— The increasing rate of world population demands for rapid improvement in food production technology. The agricultural sector has a major impact on the world economy, issues regarding which need to be solved by providing innovative solutions. The water scarcity due to the changing weather conditions and the lowering levels of underground water has given us a reason to use our water resource beneficially. About 30-35% of the crop yield is destroyed due to stray/wild animals. These issues can be solved by implementing the modern techniques into the traditional approach of farming. We propose an automatic irrigation system by analyzing the type of soil based on its water retention capacity. This approach would hoard the excessive water lost due to seepage into the lower layers of the soil. Contrarily, it would also eliminate the possibility of providing less water to the crops. In addition to that, we aim to provide farm security to protect against intruders and thieves, thereby protecting the yield. Our motive behind the project is to curb the extensive use of water for irrigation without any human intervention and send alerts for unusual activities in the farm to the user. Hence by implementing this method, we are able to save water which can be used for supplementary activities in the farm. The human effort required is reduced at an extensive level by implementing the automatic system.**

Keywords*— *automatic irrigation; soil texture; crop water requirement; evapotranspiration; farm security;

I. Introduction

Agriculture plays a vital role to strengthen the world economy. Irrigation is the backbone of agriculture which requires significant measure of human effort among all other agricultural practices. The amount of water required differs with respect to the type of crop, type of soil, growth phase of the crop and climatic conditions. Very less or too much watering can damage the crop, hence it is essential to provide the exact amount of water required by the crop. Owing to the current climatic change around the world, the underground water level is decreasing which acts as a major threat to the natural water source. This paper proposes a method to save water required for agriculture by identifying the texture of the soil. Soil can be classified based on its texture into- Sandy, Sandy Loam, Clayey Loam, Clay. The different textures can be identified based on their water holding capacity. Identification of the soil texture can help us save water in the following way, for example- If the water requirement of the crop is 100mm and if the water holding capacity of the soil is 50%, then in order to provide exact 100mm, we need to supply 200mm of water. This approach would prevent excessive water to be wasted by seepage into the lower layers of the soil. Contrarily, it will also prevent the scenario of reduced amount water supply thereby protecting the soil from extreme cases of draught or flooding.

The estimation of water requirement of crop and the nature of the surrounding farmland is essential to determine the irrigation pattern. The water demand is based on the growth stage as well as the type of crop. There are two specific ways by which water is lost from the crop. Firstly, the water uptake by the plant is lost through the stomata present on the lower side of the leaves. Secondly, when the temperature is high, the water on soil surface is lost due to evaporation. Hence, the water need of a crop consists of transpiration and evaporation, together called evapotranspiration [1]. Crop water requirements are defined here as "the depth of water needed to meet the water loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment [1]. To calculate the evapotranspiration(ETcrop) the following equation is used:

“ETcrop = kc * ETo” [1]

ETcrop is the water requirement of a given crop in mm per unit of time e.g. mm/day, kc is the crop factor and ETo is the "reference crop evapotranspiration" in mm per unit of time. The reference crop evapotranspiration ETo is the amount of water which is lost from the process of evapotranspiration from the area of the field which is completely covered with vegetation. The value of ETo depends on the weather where the hot areas have a high rate while cool and humid areas have a low rate. The crop factor (or "crop coefficient") varies according to the growth stage of the crop. This is due to the fact that the crop requires varied amount of water during its growth cycle. It requires less water during initial stages which reaches peak during the mid-season and it again requires less water as the crop matures. In this way, we can calculate the amount of water required to be supplied to the crop per day.

While taking efforts to obtain a prosperous yield, the farmer also has to monitor the security of the field to protect his crop from animals and other intruders. It is expensive and difficult to supervise the farm for the entire day manually. Hence, automating the process of supervision using a machine enhances the security and ensures that the effort of the farmer is secured. We aim to use passive infrared sensors to identify any motion on the field. Once any motion is detected, the farmer would be notified via SMS on the cell phone. Along with the alert, a series of alarms and flash lights would turn on to petrify the intruder on the farm. This approach would protect the farm from getting destroyed and also protect animal’s life by abstaining the use of electrical fences.

II. EXISTING APPROACH

As we know irrigation is an important aspect of farming. In the existing concept, the water flow is turned on by analyzing the property of soil moisture. There is a certain threshold value of moisture level decided. The water flow is turned on only if the current moisture value drops below that threshold value. Once the moisture value reaches the required threshold, then the water supply is stopped. The user can also control the motor by using a cellphone. The user can use a cell phone to send message to the Arduino which would then turn off the motor. It helps in identifying the moisture content of the plants but it fails to measure other external factors such as the soil texture, crop water requirements, temperature, weather conditions and provide a dynamic supply of water based on these parameters. Our paper proposes to tackle these limitations and come up with an effective solution to save water and human effort. There are independent systems to monitor the security of the farm by using a network of sensors and cameras. Once the system intercepts an intruder, it sounds an alarm and an SMS is sent to the user. In this paper, we propose to use the buzzer and led flash in a dynamic pattern so that the wild animals and intruders do not become habitual to the alarm system.

III. LITERATURE SURVEY

By studying the existing system of the current smart irrigation systems, we were able to find out the short comings of the system. Also, after referring various papers we were able to summarize the existing system. The papers referred are as follows:

“Intelligent Automatic Plant Irrigation System [6]”
Here, the concept is implemented using Arduino and the controlling of the motor is realized by using an Android application. The soil moisture level is monitored and water is supplied when the level drops below a threshold value.

“Intelligent Automatic Plant Irrigation System [9]”
This paper proposes to use a water pump to supply water when the value of moisture goes below the threshold value. The fan of the motor is based on the temperature of the surrounding. The system also uses the same method as above to pump water when the moisture level goes below a certain threshold.

“Smart Farm using Wireless Sensor Network [12]”
In farming temperature and humidity are the most essential parameters. The growth of crops is mainly depending on these three parameters. Currently farmers don't have any system which will show real-time levels of these parameters. Thus, the system helps farmers to take measures accordingly, based on the values of parameters.

“Design and Implementation of an Intelligent Security System for Farm Protection from Wild Animals [8]”
This paper gives us the solution to provide security to the farm by monitoring activity using sensors and a microcontroller. Here, a GSM module is used to send messages whenever there is an unusual activity on the farm.

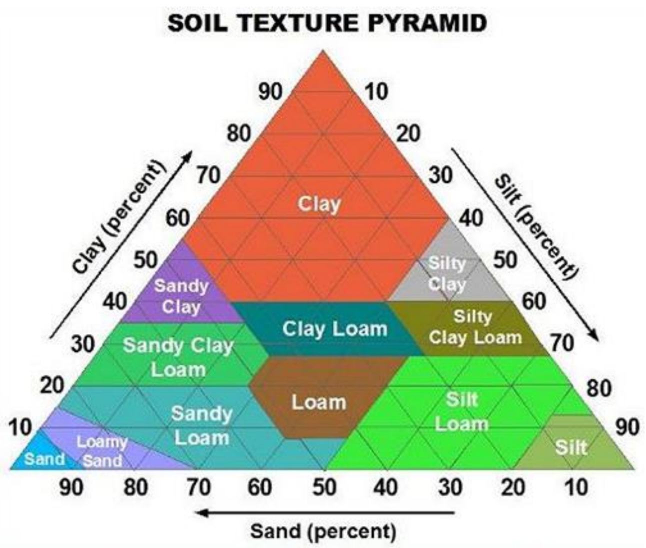
IV. PROPOSED SYSTEM

Our methodology can be divided into different parts as follows:

- Identification of soil texture
- Calculation of amount of water required by the crop
- Supplying water to the crop
- Farm Security

A. *Identification of Soil Texture*

Soil can be classified into different types based on various parameters. The soil texture is one such parameter that we propose to use since the probability of variance with respect to time is minimum. This process would be a one-time analysis of the soil. The materials required for the test are Shovel, water, ruler, indelible marker, jar, detergent. Now, we remove the top 2 inches of the soil and clean the roots, twigs, rocks and deposit one-third soil sample in a jar. Then, we add water and detergent to the jar and shake it well. The heavy particles settle down first followed by the light, fine particles of silt. Mark the sand level on the jar after each layer is clearly seen. Now, calculate the ratio of different soil levels and thereby obtain the relative percentage of each soil level. Now, we can refer the soil pyramid below to find the soil texture of the particular sample:



Now, based on the texture of the soil, each type of soil has a specific water retention capacity. We propose to use this water retention capacity while supplying water.

B. Calculation of the Crop Water Requirement

Crop water requirement is the most important factor to be decided during the process of agriculture. To measure the crop water requirement for a particular crop per day, the ET of the crop is calculated as

“ETcrop = kc* ETo “[1]

Here, ETo is the reference crop evapotranspiration value which can be found using the Blaney Cridle method. The empirical formula to calculate the ETo is given as:

“ETo = p (0.46 * Tmean + 8)” [1]

Here, Tmean is the mean daily temperature which can be calculated by knowing the maximum temperature (Tmax) and minimum temperature(Tmin) using the formula:

“Tmean = (Tmax + Tmin)/2” [1]

Based on the latitude for that particular region, we can set the value of p accordingly for each month. The following table shows the different values of ‘p’:

Latitude in ° North	J	F	M	A	M	J
60	4.67	5.65	8.08	9.65	11.74	12.39
50	5.98	6.30	8.24	9.24	10.68	10.91
40	6.76	6.72	8.33	8.95	10,02	10,08
35	7.05	6.88	8.35	8.83	9.76	9.77
30	7.30	7.03	8.38	8.72	9.53	9.49
25	7.53	7.14	8.39	8.61	9.33	9.23
20	7.74	7.25	8.41	8.52	9.15	9.00
15	7.94	7.36	8.43	8.44	8.98	8.80
10	8.13	7.47	8.45	8.37	8.81	8.60
0	8.50	7.66	8.49	8.21	8.50	8.22
South						
10	8.86	7.87	8.53	8.09	8.18	7.86
20	9.24	8.09	8.57	7.94	7.85	7.43
30	9.70	8.33	8.62	7.73	7.45	6.96
40	10,27	8.63	8.67	7.49	6.97	6.37

To account for the effect of the crop characteristics on crop water requirements, crop coefficients (kc) are presented to relate ETo to crop evapotranspiration (ETcrop). The values of crop coefficient are dependent on the growth phase of the crop. The value of kc changes throughout the growth period, hence for calculation purposes we use the average of all the kc values. The kc values of common crops are given as follows:

Crop Name	Values of kc
Cotton	0.82
Maize	0.82
Millet	0.79
Sorghum	0.78
Grains (small)	0.78
Legumes	0.79
Groundnuts	0.79

C. Water Supply

Using these values of ETo and kc, we can determine ET which gives us the water requirement on a daily basis as stated above. Since we know the values of daily water usage of the crop and the water holding capacity of the soil, we propose to use both to efficiently supply water to the crop using a water pump connected to a relay which is in turn connected to the Arduino Uno. ETcrop gives us the amount of water (in mm) to be supplied for a single day. To calculate the actual amount of water required (in liters), we use the following formula:

Amount of water required= ETcrop* 1000* Area of farm (in square meters)

Since we know the values of daily water usage of the crop and the water holding capacity of the soil. The amount of water supplied can be calculated by the formula:

Amount of water to be supplied = Amount of water required / Soil water holding capacity %

The total amount of water to be supplied can be distributed at particular intervals during the entire day to ensure uniform seepage of water to the crop.

D. Farm Security

We propose to protect the farm by installing PIR sensors diagonally in the middle in an attempt to cover the entire radius of the field. Every living being naturally emits a radiation which can be intercepted using a PIR sensor. When intruder passes in the field, the radiations at that point will rise from room temperature. The PIR sensor operates at an angle of 15 degrees, thereby providing an extensive support.

Once an intruder enters the farm, the PIR sensor will sense a change in the value of infrared radiations and immediately a buzzer would be triggered on. Subsequently, the lights would be switched on, flashing at a varied rate. Hence, the intruder would be alarmed and the farm would be protected. The sensors would be switched off after a certain time interval. A certain buffer period would be set after that particular time interval so that there is no definite pattern followed by the system to refrain the animals to be habitual to a particular alarm pattern. Additionally, an automatic SMS would be sent to the farmer's cellphone using a SIM900A GSM module which is attached to the Arduino Uno. These measures would ensure that the intruder has left the field and the farmer is notified for the same.

V. OVERVIEW OF THE SYSTEM

Currently, water shortage is one of the biggest problems in the world. The system ensures that external factors such as . Automatic irrigation is the process of supplying water to the crops without the involvement of a human. The water is supplied to the crops using a network of sensors and actuator. Farm Security deals with the protection of the yield from unwanted intruders like animals, birds or thieves. It is an important aspect of farming as the loss of yield will lead to an in-turn loss of investment and efforts. Water is extensively used in the process of farming; hence we must strive to conserve it in every way possible.

VI. CHALLENGES IN IMPLEMENTATION

Energy is an essential entity of irrigation. The problem is that such projects are usually away from the city, and their level of consumption cannot be supported by the local- low voltage transition line. The unpredictable nature of weather may also prove to be a major hindrance in implementation of the system. Unexpected heavy rainfall may hamper with the amount of water supplied to the crop. Hence this system can be extensively used at places where irrigation is the main source of water supply.

VII. CONCLUSION AND FUTURE SCOPE

We have started with a simple idea of automating the plant irrigation system. In this paper, we have mainly focused on improving the existing plant irrigation system and farmland security. Currently, the system is proposed for irrigation and farmland security models but the same can be further extended to work with more sensors. More external factors can be considered such as humidity, wind speed which changes the rate of evaporation. Furthermore, the system can be extended to automate the process of identifying the soil texture. We can install a camera in the farm and develop a mobile application to stream the live feed to the app.

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