IOT and Machine Learning Based Soil Moisture Prediction and Monitoring

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Abstract:- Agriculture plays a crucial role in the overall growth of the nation. Around 70% of the population is directly or indirectly dependent on irrigation, while about one-third of the country's (India) revenue is obtained from agriculture. Even so, the demand for food is increasing day by day and may continue to do so for decades. To solve this exceeding demand a feasible solution would be to use smart-farming techniques to enhance effectiveness and productivity and reduce manual labour, latency and overall expenses. But the farmers in the developing nation mainly rely on the traditional farming methods as they smart-farming techniques are expensive. Our paper addresses this issue of affordability by incorporating IoT and machine learning-based design that will help farmers monitor the soil quality based on the moisture content present. This paper proposes a system which will monitor the environmental factors using IoT and determine the moisture content of the soil. With the help of the data accumulated, machine learning is used to predict the future soil moisture. And lastly, a basic GUI is implemented to take environmental parameters as input and output of the soil moisture.

Keywords:- *Agriculture, Soil Moisture, IoT, Machine Learning, GUI*

I. INTRODUCTION

Agriculture is critical to the Indian economy. It supports more than 70% of rural families. Agriculture is a major sector of the Indian economy, accounting for approximately 17% of total GDP and employing more than 60% of the workforce.

Water is a key input in practically every phase of agriculture, with a decisive effect on the final yield. If plants are not properly watered, even the best seeds and fertilisers will not reach their full potential. Also, climate change has led to a worrying trend of no rain for longer periods, which significantly affects crop growth. Not to mention droughts which have severely impacted the economy, society and environment affecting crops, irrigation, wildlife, soil etc. This paper introduces a water system framework for farms using devices such as orange pi, soil moisture sensors, temperature sensors etc which will in turn help in the conservation of water and reduce the wastage of this resource.

A farmer's decision on which crop to cultivate is usually influenced by his intuition as well as other irrelevant factors such as generating quick money, being unaware of market demand, overestimating a soil's ability to support a specific crop, and so on.

The need of the hour is to create a system that can provide Indian farmers with predictive information, allowing them to make better decisions about which crops to produce. Increased crop yields, water savings, protection of local water resources from runoff, reduced energy costs, reduced fertiliser costs, and increased farm profitability are all advantages of optimising irrigation schedules with soil moisture sensors. This necessitates smart farming, which necessitates the use of IoT.

Agriculture using IoT might be a game-changer for humanity and the entire planet. Farmers will gain valuable insights into the functioning of their crops, greenhouses, and other agricultural activities thanks to sensor data analytics.

Machine Learning-powered farming, with its high-precision algorithms, is a new concept that is gaining traction today. This cutting-edge trend, which aims to raise the quantity and quality of products, ensures long-term productivity growth for everyone involved in agriculture.

II. IOT

A. Model Components:

- Orange Pi: It can run Android 4.4, Ubuntu, Debian. It makes use of the AllWinner H2 SoC, and has 256MB/512MB DDR3 SDRAM (256MB model is Standard model. It behaves like Android which helps the users to try different projects in the system.

- Soil moisture sensor YL 100: The soil moisture sensor operates in a reasonably smooth manner. The fork-fashioned probe, which has uncovered conductors, capabilities as a variable resistor (much like a potentiometer) whose resistance fluctuates with the quantity of water withinside the soil.

- Signal Conditioning and Comparator LM-393: The module consists of an integrated potentiometer for adjusting the virtual output's sensitivity (DO).

- DHT11: The sensor includes an electrical module that links the probe to the Arduino. The Analog Output (AO) pin of the module creates an output voltage dependent on the resistance of the probe. The signal is digitised by an LM393 High Precision Comparator and then made available through a Digital Output (DO) pin.

- Weather API: A Weather API is used by developers to create interactive apps that deliver important information to clients. Weather APIs are necessary not only for forecasting future weather, but also for obtaining historical data.

- Pressure sensor: A pressure-sensitive element determines the actual pressure applied to the sensor, and other components that transform this information into an output signal are included in these pressure sensors.

- Amazon AWS: AWS Lambda is Amazon's serverless computing service, that's a part of Amazon Web Services. AWS lambda lets you run your code while not having to fear the infrastructure.

B. Working:

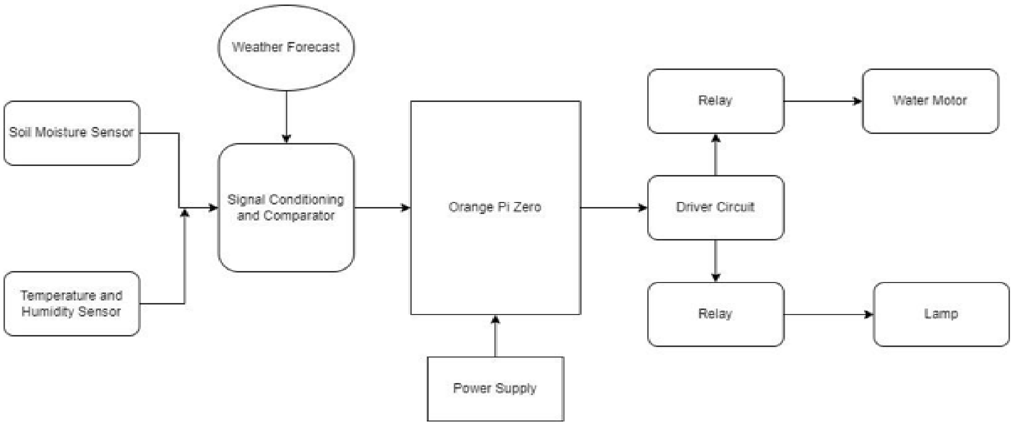

Fig 1:- System Architecture

In the above design, Orange Pi Zero is used with the aforementioned sensors which will provide moisture, temperature and humidity value and this data will be sent to signal comparator. Instead of taking readings of wind speed and pressure from sensors on the field, data has been taken from the weather forecast API. So, using the weather API for getting the values which will be sent to Orange Pi. Orange Pi will be connected to the power supply as given in the above design. Then the values will be displayed and later it will calculate and show the moisture present in the field. Which will help the farmer to gain knowledge about the percentage of water present in the crop and accordingly irrigation will be done. This collected data will be sent and stored in the cloud for further machine learning computation. The cloud framework design is given in the figure below.

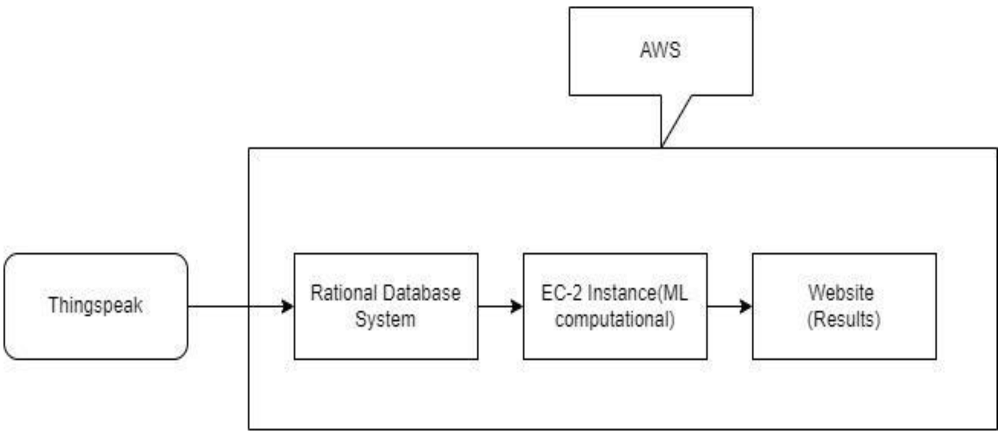

Fig 2:- Cloud & ML design

III. DATASET

This dataset was collected as part of an experiment using IoT sensors over 4 months in 4 fields growing maize and peanuts in Senegal.

An IoT sensor was placed in four distinct plots of land that were planted with either maize or peanuts. The plots are right next to each other, separated by a one metre perimeter. The features of the dataset are as follows: Timestamp, Soil moisture (Volumetric %), Air temperature (Celsius), Air humidity (%), Pressure (KPa), Wind speed (Km/h), Wind gust (Km/h), Wind direction (Degree).

IV. MACHINE LEARNING

- *Multiple Linear Regression:*

It's a widely utilised regression technique for a wide range of issues. Multiple linear regression assumes that the variables have a linear connection and attempts to fit all of the data points with a straight line while minimising residual error. It's an extended kind of linear regression. It is more prone to outliers because it considers all data points when determining the best line.

- *Support Vector Regression:*

The support vector regression is based on the concept of vectors, and it is less prone to outliers as it's dependent on specific data points. The loss function for regression tasks is set up so that it ignores errors for data points that are within a specific distance of the correct values. There are different kernels used in SVM: linear, polynomial and rbf.

Linear Kernel Formula: **F(x, xj) = sum(x.xj)**

Polynomial Kernel Formula:
F(x, xj) = (x.xj+1)^d

Gaussian Radial Basis Function (RBF):
F(x, xj) = exp(-gamma * ||x - xj||^2)

- *Random Forest:*

Random Forest Regression is a Supervised Learning algorithm and is a form of ensemble learning which is good at learning complex and non-linear relationships. The input data is passed through multiple decision trees at training time and the output is the class that is the mode of the classes (for classification) or mean prediction (for regression) of the individual trees.

- *Decision Trees:*

In practice, decision trees are one of the most widely used predictive modelling methods. A regression tree is a decision tree that is used to forecast continuous valued outputs rather than discrete outputs for the purpose of regression.

V. RESULTS

After analysing the performance of each model using its corresponding performance metrics, they can be compared to get the most suitable model for our problem statement. The results are shown in the table below:

	MSE	RMSE	MAE	R2	Adj_R2
Linear	76.756544	8.761081	6.711268	0.231273	0.230756
RF	0.070968	0.266398	0.067281	0.999289	0.999289
DT	0.103233	0.321300	0.079628	0.998966	0.998965
SVM	12.856845	3.585644	2.277617	0.871237	0.871150
SVM_Poly	40.148788	3.585644	4.201896	0.597905	0.597634
SVM_Lin	82.139051	3.585644	6.453811	0.177367	0.176813

Table 1:- Performance Metrics

The best performing model (Random Forest) is then used for the prediction by the GUI. This Graphical User Interface allows for single predictions according to parameters to take place.

VI. CONCLUSION

In summary, this paper uses different machine learning algorithms such as random forest, SVM and more which verifies the accuracy of the result. The system monitors the behaviour of soil moisture, air humidity and air temperature and sees how it contributes to evaluate the need of water in a plant. This predicted soil moisture level assists the farmers to optimize their water delivery and manage their water reserves to prevent scarcity of water sources and damage to the crop. The larger coverage area of the model will further increase usability and lower costs.

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