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Research Article

E-Agronomy: Smart irrigation decision making system using Machine learning in Precision Agriculture

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Abstract

Agriculture is the backbone for a developing country like India, and there is a vast need to maintain the agricultural property. Precise agriculture is a significant contribution to the economic and agricultural welfare of countries across the globe. Effective utilization of agricultural land and irrigation guaranteeing food safety. This proposed decision-making system proposes nursing the Internet of Things (IoT) and micro litre-based agriculture system. This system will assist farmers or agriculturists in maintaining a proper irrigation schedule, leading to solid root development with minimizing water loss. IoT technology and Machine Learning (ML) for the prediction will change sensible farming and increase their overall yield with minimum water. The smart irrigation decision-making system designed using a decision tree algorithm, which trains the system using the gathered soil and methodological parameters to decide the amount of water to irrigate.

Key Words: **Agricultural Meteorology, Crop Prediction, Internet of Things, Machine Learning, sensible Farming**

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Introduction

The development of intelligent, sensible farming devices supported by the Internet of things and computing is turning the face of agriculture production day by day by enhancing it, however, conjointly creating it cost-efficient and reducing wastage. In recent years, the drastic changes in agriculture due to poor climate conditions, unpredictable weather, population growth, migration, and urbanization. Those reasons lead to food scarcity. New technological solutions are needed to resolve food scarcity. According to WHO research, we need 50% of other food in 2050 if world population growth is continuously rising. Due to climate changes, the crop yield is falling by 1/4 percentage. The globe is moving into a brand-new technology, and these technologies are used in agriculture to increase the yield of crops and reduce water usage. The implementation of sensible technology in agriculture practices needs to target higher land productivity. Such studies area unit conducted in natural out of doors environmental conditions and locations wherever crops area unit growing, by varying metrological and physical conditions. The Internet of Things (IoT) and AI technologies combine will lower the value and increase the dimensions of such studies via the gathering of connected time-series information from sensing element networks and labs observations recorded by testing them with chemicals [1]. The Agriculture system proposed during this paper is associate in nursing integration of the ideas of Machine learning and IOT victimization. By using IoT boards and various sensors, through that live information feed may be obtained and processed [2].

Literature Survey

This proposed work relies on IoT [1] and Machine Learning. Principles of scientific agriculture and Agricultural Meteorology area unit the key ideas that area unit enforced for predicting the favorable crop. Presently for this proposal, the earth science information of Bidar, Karnataka, is taken into thought. Several Sensors area unit concerned with collecting varied earth science and Edaphic Factors information. In the following area unit, the Hardware and code need to execute the blooming technology in recent years. Cloud and IoT influence agriculture with cost reduction with increasing yield [2]. The author [3] recommended using a wireless sensor for monitoring the crops with different temperatures, minerals and moisture levels.

The author [4] control the irrigation system remotely by implementing IoT technology. The fuzzy-based framework for advanced irrigation system with moisture detection, temp, humidity and air sensors [5]. The microprocessor raspberry pi perceives the input data from the wireless devices, and electrical units control it by the author [6]. The author [7] developed a multi-level irrigation method to alleviate water consumption based on soil moisture and temperature condition. The water released from the pump and the same intimated to the farmer [8]. The above-said System is helpful in water scarcity regions. The author studies soil parameters and monitoring the soil condition to do the automatic irrigation [9]. The author has prepared the survey paper [10] to find the parameters in irrigation system such as water quantity, soil parameters, and meteorological conditions. The closed loop irrigation system for precision agriculture is discussed [11]. The Enhanced Neuro Genetic Model (ENGM) for Precision Agriculture is discussed for precision agriculture [12].

Agricultural Meteorological Factors

The agricultural meteorological is a subdivision of applied meteorology that examines crop physical conditions and trade in the correlation between the meteorological condition and crop production. The term 'Agro Meteorology' is studying the interaction between earth science and the hydrological components. Meteorological factors play a significant role in crop production, and the yield depends on climate conditions that influence crop production. The meteorological factors are Atmospheric precipitation, Temperature, Humidity, Solar light intensity, Soil wetness, Organic components, Soil minerals and Soil hydrogen ion concentration. The key elements and protocols are discussed by authors[13].

Atmospheric precipitation

The atmospheric precipitation contains the water that received from the atmosphere, such as dew moisture, Snow. Precipitation is the primary factor in the vegetation of a specific region. Precipitation influences the species and equally allocated in the agriculture areas. A crop like tea, rice, coffee, rubber requires equally distributed precipitation; uneven allocation of the precipitation is general in dry land and the crops cultivated are millets, sorghum and Pennisetum Americanum. The equal dissemination of precipitation is needed to grow plants evenly. Farmers within developing countries like Asian country rely on the annual precipitation for Irrigation Purpose.

Temperature

The variation in temperature affects the growth of the plants. The low temperature leads to suffocation, freezing and chilling injury. Simultaneously, high temperature causes changes in minerals contents, leading to pollen development and shoot growth. The temperature affects the crop growth cycle from germination of the seed to crop development. The gas diffusion and changes in liquid in the atmosphere are affected by temperature. The cardinal temperature defined as the high, low and medium temperature of the plants.

Humidity

Humidity is the quantitative relationship between the wetness and saturation capability of air. The humidity range is between 40-60% is suitable for crop plants—the air temperature regulated by humidity and higher atmospheric vapor content. The humidity is 100 per cent in saturated air.

Solar light intensity

The sunlight is the primary source of the ecosystem and organisms' growth, which acts as a significant part of the crop and its production. The cycle from germination to post-harvest crop is under radiation, and the whole physical process happened within the soil, atmosphere, land and plants are depends on solar energy. Solar radiation is essential in a chemical change in plants. Carbohydrate production is vital for active radiation mechanism.

Soil wetness

Water is an essential component of growth that absorbs from the soil. Water is a rudimentary component of the chemical process. The soil moisture changes from cubic measure and wilting. The water content in soil assists the plans for biochemical activities.

Soil minerals

The soil minerals accumulated from rocks weathering and mineral particles of various dimensions, and the primary sources of soil nutrients are calcium, magnesium, sodium, ferrous and potassium. The organic particles and acids discharged from the organic particle decomposition permit the mineralization activity. The chemical analysis of soils and is well recognized as a scientific means for fast characterization of soils' fertility status and predicting the nutrient demand of crops. Though plants absorb an outsized range of parts, they are not essential for the expansion of crops. The elements are absorbed. They happen to be within the soil solution, and people are taking active half within the growth and developmental processes referred to as the essential ones. Some of these needed in giant amounts and a few in traces.

Soil hydrogen ion concentration

Minimum hydrogen ion concentration additionally interferes with the convenience of different plant nutrients. Soils fashioned beneath low precipitation conditions tend to be essential, with soil hydrogen concentration readings around seven. Intensive farming overhead in different years with gas fertilizers or manures may result in a natural soil process. For example, that has a soil hydrogen ion concentration of five. The hydrogen ion concentration in soil affects crop growth, and 7 is the hydrogen ion concentration for best growth. The soil ph value is <7.0, it is acidic, >7.0 alkaline and =7.0 saline soil with less hydrogen ion is dangerous to plants.

Methodology Used in the Proposed Work

Decision tree

The decision is worked based on the hierarchical tree structure. The logic rules explored in tree using patterns. The nodes classified into internal (leaf) and external (terminal), connected by branches. Actions calculate every area assigned with labels and data points, and an internal node is a decision-making unit that decides the next child node to be visited. Classification and regression are the primary types of the decision tree. The external node in the regression tree is constant that forecasted the output value. The internal node of decision tree in classification contains the labelled data. The irrigation events like irrigate and not irrigate is defined. The decision support system developed using decision trees that provide greater accuracy than the discussed support vector machine. The proposed decision tree algorithm assists in soil moisture prediction using temporal dependencies.

Support vector machine

The support vector machine (SVM) is a linear classifier that find a hyperplane in a multidimensional space with n number of data points. Hyperplane acts as a decision point that helps to segregate the data points. The hyper plane constructed dimensionally and the higher dimensional space define the problem of crop irrigation demand. The rudimentary idea of SVM classifier divided into two: finding an optimal hyper plane that fulfils the classification request and ensuring the accuracy of classification margin separation performed in the optimal hyperplane. Then the data can be divided into classes. In the SVM classifier the training dataset can be defined as {(a1, b1), (a2, b2),…., (an, bn), where a is an input vector and b is a label. The hyperplane is defined as

$$\omega . a + x = 0$$

Where **ω**is the normal vector and x is the hyper plane offset.

Root Mean Error Square (RMSE)

The root mean error square is the traditional way to measure the error in the derived model based on qualitative analysis data.

$$\mathrm{RMSE} = \sqrt{\sum_{p=1}^{N} \frac{(\hat{y}_p - y_p)^2}{N}}$$

Where ŷ are the predicted values, y is the observed values, and N is the number of observations. The Euclidean distance of two vectors is calculated by

$$d(\mathrm{a}, \mathrm{b}) = \sqrt{\sum_{p=1}^{N} (a_i - b_i)^2}$$

Mean Squared Error (MSE)

The mean square is the average of the square of the difference between the actual and estimated values. MSE is used to predict the sample quality.

$$\mathrm{MSE} = \frac{1}{N} \sum_{p=1}^{N} (y_p - \hat{y}_p)^2$$

Variance (σ^2)

The measurement of the spread of numbers in a dataset is the variability from the average mean. The variance calculated by considering the difference between every number in a dataset and its mean, squaring the difference to make it positive and dividing the cumulative sum of the square of numbers in a dataset.

$$\sigma^2 = \frac{\sum(y_i - \hat{y})^2}{n - 1}$$

σ^2 is the variance, y_i value of the observation, $\hat{y}$ is mean of all observations and n is number of observation.

Proposed Methodology

The System designed with varied sensible technologies and IoT for Sensors Sensing, Machine learning for prediction purpose, Web Technologies for forepart user interface (UI) style and info style are concerned for this abstract style. This technique collects the device information for over an associate degree Agri-Season (Min. 6 Months). The proposed methodology divided into diverse phases such as flow of events, experimental setup, Information configuration, Machine learning model configuration, and training data collection. Raspberry Pi and NodeMCU used by using various sensors. The inputs perceived from the environment. These sensors are constantly monitoring the environmental conditions and do the irrigation process. Figure 1 shows the primary facilitators of the proposed work.

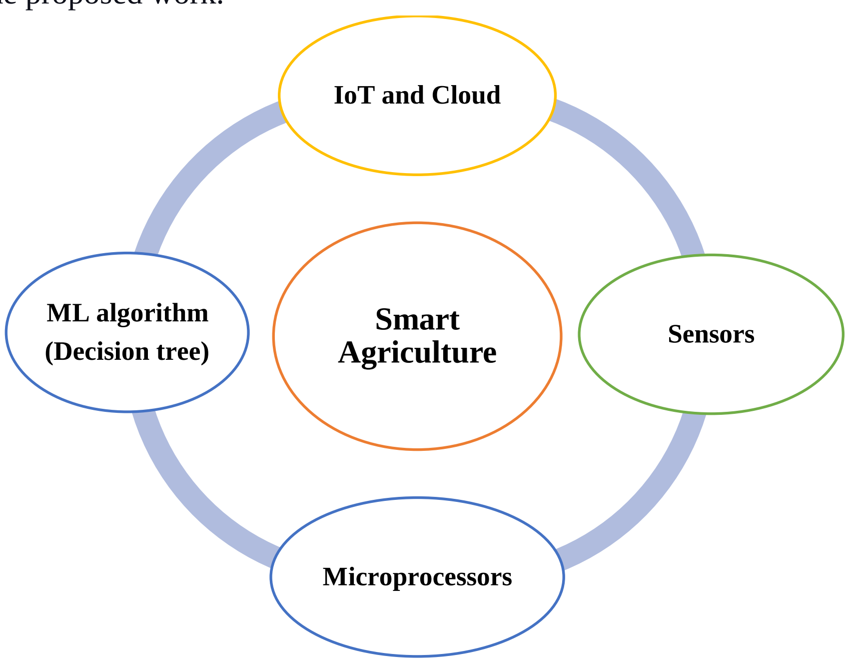

Figure 1 Primary facilitators of proposed work

Flow of Events

The flow divided into multiple significant sections, such as A) Sensing of parameters victimization IoT Boards and Sensors. B) Science lab Tested / Physical Parameters information ought to be stored. C) Storing of those information inputs received from the IoT boards and Testing Labs. D) Optimizing this computer file for more process. E) Process this optimized information by the milliliter Model for the final Prediction.

Experimental Setup

The intention of this work is to extracting device information from the agricultural field. This agricultural process may achieve through the victimization of raspberry pi and Node MCU ESP8266 Controller Boards. Numerous attributes will be accessed victimization sensors through these boards. Boards programmed through python IDE raspberry pi. The objective is to store the data from sensors and accumulated it in a database. The MySQL Server will continue storing the sensor knowledge Device connected to a neighborhood server will insert the inputs exploitation POST/GET requests. This knowledge mapped and lessen for best results. SQL (Structured question Language) for knowledge retrieval and storing.

Net Technology Configuration

Apache Server and Flask WSGI Server because the Web Servers square measure used. PHP, HTML, CSS languages as backend and U.I languages square measure used. The objective of net technology configuration is listed. The U.I style for Lab-tested inputs on with detector knowledge

- Dominant detector knowledge
- Detector knowledge extraction from the information
- U.I for Lab-Tested parameters
- Connecting to the Machine Learning Model
- Causation knowledge to the present trained M.L Model
- Receiving the Output responded by M.L Model
- Displaying the expected Output

Machine Learning Model Configuration

The objective of this Model is to coach the Model for Prediction. The Model to be trained exploitation the Dataset of past results supported scientific discipline parameters. Optimizing the Model for additional correct results and SciKit tool in python is used to analyze the input data. Currently, the Model trained for three significant crops widely grown in the regions of Bidar District. i.e. Toor Dal, Sugarcane, Soya bean. The Dataset extracted from the Farmers Soil Health card [14], which issued during a seasoning period Metrological Data for over some time is used from the worldweatheronline.com portal for training purpose. A decision tree used to represent decision making, and it uses a tree-like structure.

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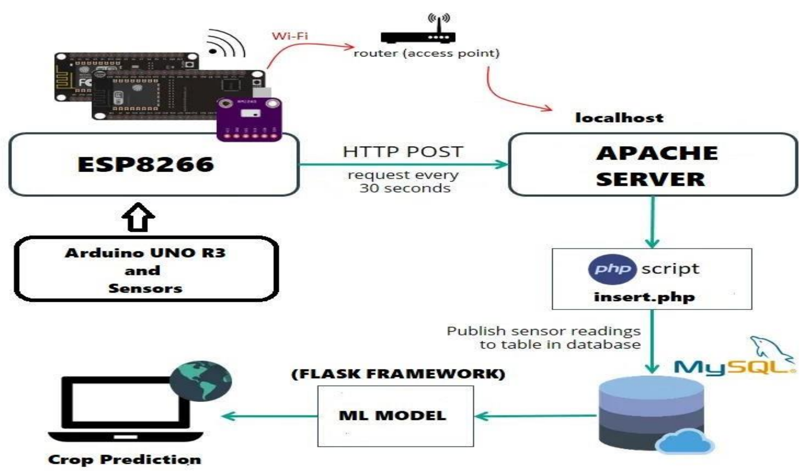

Figure 2 Apache server communication

POST request to the Apache server to store the MySQL sensor data Database. This data insertion process into the database is done repeatedly for over some time/Seasons—this data from the database and the other lab-tested parameters senig 3t to the ML Model for the Prediction. The Predicted output displayed on the Web portal accessed from the Internet and the ESP8266, Apache Server, Flask Framework WSGI Server and MySQL Server, configured with IP address and Ports. All these devices brought under a common platform named local LAN Network. For every 30 seconds time interval, a POST/GET request sent from the ESP8266 to the Apache Server, where the PHP code written for the database insertion of this sensor data executed.

The primary step in intelligent agriculture is to lay the sensors in the field to identify the environmental conditions. The gateway node gathers the data from the sensors node and transfers it to the cloud for analysis. The Raspberry pi works as a gateway between the sensor nodes cloud environment and has an inbuilt wifi module, relay module, and pins for connecting the sensors. The Raspberry pi microprocessor has the fundamental transmitter signal, receiver signals and pins.

Data analysis process-decision tree

The decision tree maps the reasoning process helps to categories the tasks into Separate classes. The Classification and regression Technique (CART) performs the recursive process for partitioning. In this procedure, the parent node divided into child nodes and recursively, the process repeated by the child node act as a parent node. The partitioning process is happening until the threshold value or impossible to divide the parent node. The algorithm repeats the procedure until the initial terminal node has created.The Internet of Things based architecture proposed to collect, correlate and transmit the data. The architecture shown in figure 4 and divided into three primary layers: The application layer, the Data processing and decision-making layer and the Data cell and transmission layer. The application layer contains meteorological data from the weather station. This help to predict the irrigation of upcoming days. The centralized server act as a database for storing the data from weather stations and the external environment through the raspberry pi microcontroller and the irrigation planning and future crop prediction based on real-time data.

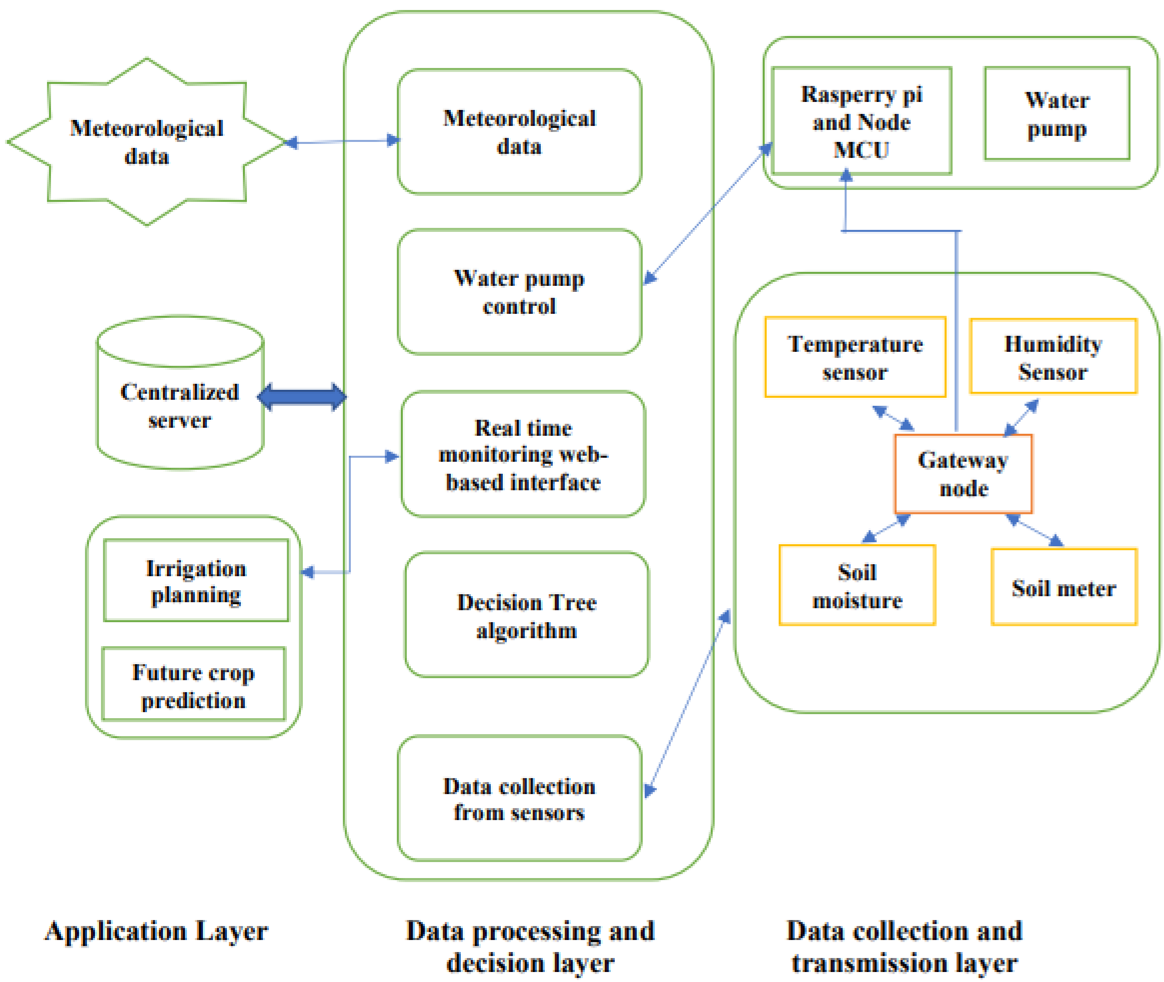

Figure 3 The architecture of proposed work

The data processing and decision making layer contain theological data collection from the weather station, controlling the water pump based on atmospheric condition; Real-time data monitoring and the analysis made using a decision tree algorithm.The data collection and transmission layer contain Raspberry pi as a microcontroller to control the water pump. If the soil contains minimum moisture, the water pump gets on—the gateway node with various sensors such as temperature, humidity, soil moisture and soil meter. The soil meter sensor used to predict the soil's light and PH level, identifying the suitable crop for the next cycle. Figure 3 shows the architecture of the proposed work.

Results and Discussion

In this proposed work we used the irrigation dataset, preprocess the dataset and compare the efficiency with the support vector machine and decision tree for calculating the root mean squared error, variance and soil moisture difference. The soil moisture difference of existing support vector machine and proposed decision tree is evaluated. The proposed decision tree values closely related to soil moisture difference when compared to existing support vector machine. The Comparison of SMD, SVM and DT in terms of Soil moisture predicted is shown in figure 4.

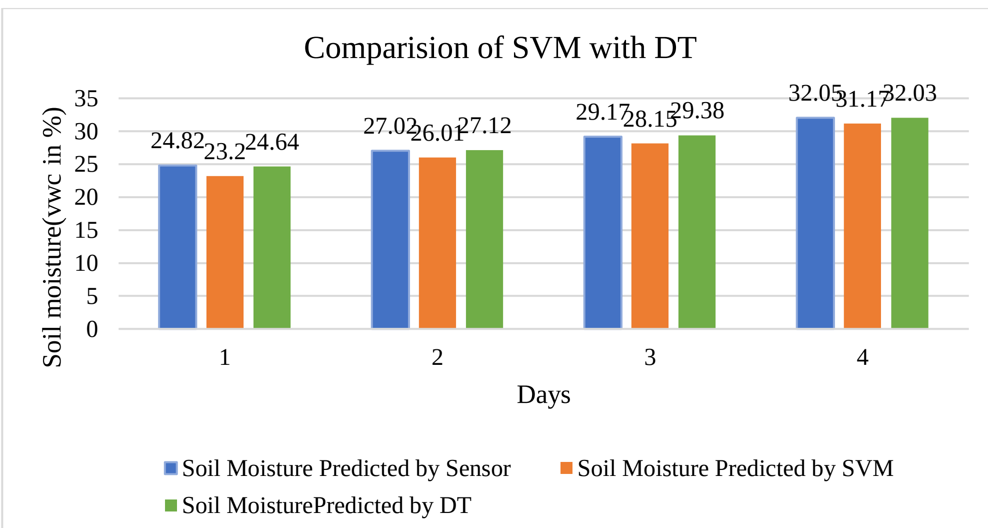

Figure 4 Comparison of SMD, SVM and DT in terms of Soil moisture predicted

The RMSE is calculated for Support vector machine and decision tree, in which decision tree have less root mean squared error as 0.52, 0.43, 0.52, 0.51, 0.52, 0.42, and 0.53. The performance evaluation of SVM and DT in the terms of RMSE is shown in figure 5.

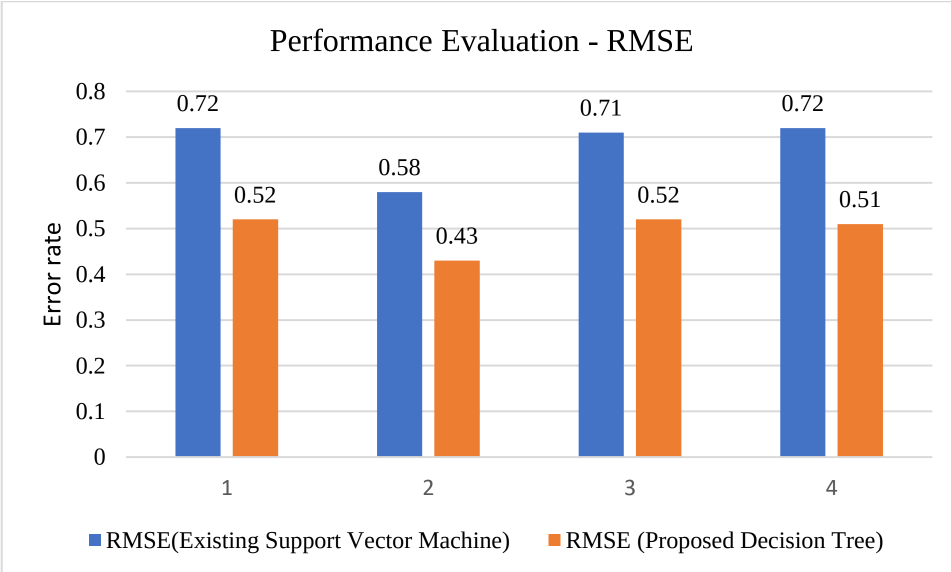

Figure 5 Performance evaluation of SVM and DT in the terms of RMSE

The R^2 of existing support vector machine and proposed decision tree is evaluated. The proposed decision tree gives values as 0.961, 0.969, 0.962, 0.974 when compared to existing support vector machine. The Performance evaluation of SVM and DT in the terms of $R^{2\ \text{is}}$ shown in figure 6.

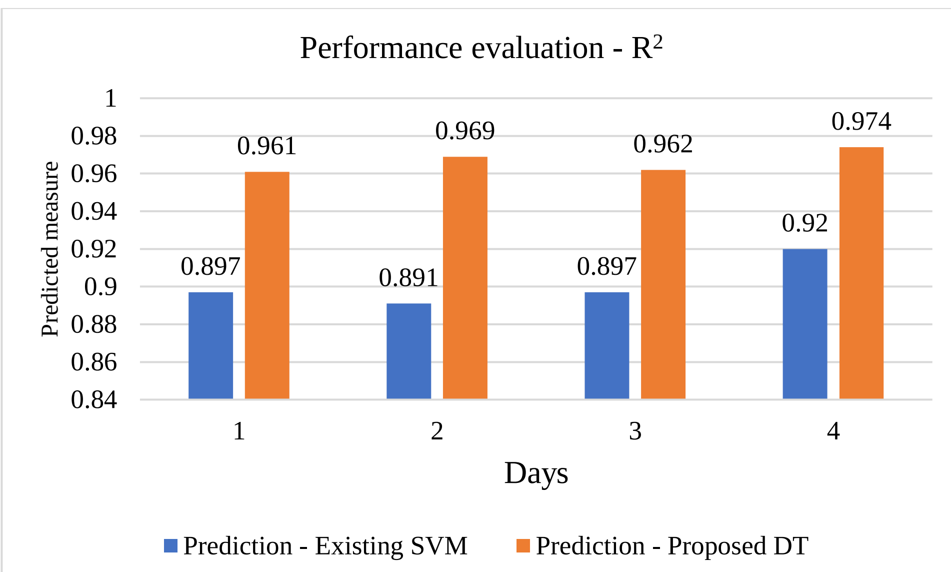

Figure 6 Performance evaluation of SVM and DT in the terms of R^2

Conclusion

Irrigation is the most challenging task in the precision agricultural domain. Farmer or Agriculturist tends to use primitive irrigation methods, leading to water waste and affecting crop growth. The proposed method helps the farmers to predict the required water for the field precisely, and irrigation made accordingly. The proposed method developed using a decision tree tested and evaluated, and the results show that the proposed method is suitable in precision agriculture to predict irrigation precisely.

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