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A PROACTIVE WATER MANAGEMENT USING MACHINE LEARNING IN PRECISE IRRIGATION SYSTEM

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Abstract— The global warming and climate change is a one of the main reason for shortage of water. Therefore, smart use of water resources is necessary for long-term sustainability. In different large-scale water consumer industries, the agriculture is one of the key consumers. The utilized water in this industry has polluted and not being utilized as fresh water. Therefore, optimization in water management systems in agricultural irrigation system is required. In this paper, we provide a study of the components utilized for designing a smart irrigation system. The key components are: (1) soil moisture and temperature based water prediction (2) weather prediction module and (3) the application of both in irrigation system automation is simulated. The problem of water management has formulated as proactive resource management. Therefore, the prediction of weather conditions and sensor readings has used to map these readings to water supply treatment. The Artificial Neural Network (ANN) and Support Vector Regression (SVR) algorithm has used for classification task. The model has evaluated against two datasets and performance has measured in terms of accuracy and training time. The different experimental scenarios has considered for discussing the performance of the proposed irrigation management system. The result shows the ANN is accurate as compared to SVR, but SVR is efficient in training as compared to ANN. Finally, the conclusion of the work has provided and future extension of the work proposed.

Keywords—Machine learning, algorithm designs, support system, irrigation system, sensor network, prediction, automation.

I. INTRODUCTION

The machine learning techniques can be used in various real world problems for prediction and classification. The prediction aims to approximate a continuous value but in classification the category or label is needed to be predicted. In this presented work the machine learning techniques are used for decision making process. The continuous data as input is taken into account and category of water treatment is predicted. In this scenario, the data collection and making it learnable for machine learning module is a challenging process. Therefore, the time series data analysis and their transformation are needed to be including in initial process of data processing. Therefore the proposed work first includes the data exploration and transformation and then explores the techniques for learning and prediction. In order to use the ability of machine learning techniques the remote irrigation system is considered. That technique provides the automated decision making ability for precise water treatment decision making.

In common farming process irrigation decisions are highly depends on the soil conditions such as temperature and moisture. In addition, the weather conditions are also highly influencing variable for accurate decision making process in smart farming applications. In this presented work, the machine learning system is proposed to address this decision making complexity.

The proposed technique map the irrigation decisions based on the relationship between the soil temperature, moisture and weather conditions. The obtained relationships and the normalized and transformed data are used to train an artificial neural network. The trained model is further used for predicting the decisions based on the current sensor readings. The proposed system is experimented with the fusion of two different datasets based on weather conditions and soil and moisture datasets. This section provides the basic overview of the proposed system next section provides the detailed understanding of the functional aspects of the proposed irrigation system.

II. PROPOSED WORK

The water resources are limited and in agriculture a significant amount of fresh water is required. The water is also being populated after utilization in agriculture practice. On the other hand due to global warming and climate change motivate us to preserve the water. In this context, the proposed work is focused on preserving water utilization and wastage in agricultural practice. However, the resource management techniques based on machine learning we can preserve the valuable resources. Therefore, we need an accurate and efficient water management system in agriculture. In literature the precise irrigation systems are used for controlling the water utilization and wastage. These systems are monitoring the farms and based on the requirements the system irrigate the crops. By appropriate utilization of water we can reduce wastage and also help to improve the production of crops. In this context the proposed work is aimed to design and develop an efficient and accurate decision support model for minimizing water requirements in agricultural needs. The proposed design of irrigation system is to utilize the concept of proactive resource management.

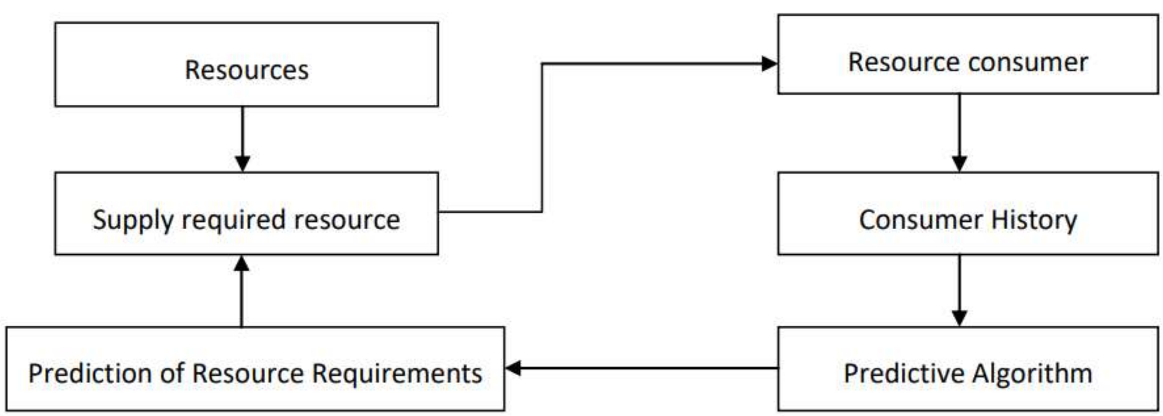


Figure 1: Proactive resource management techniques

A basic proactive resource management technique is demonstrated in figure 1. Additionally the key components of the model are also given. According to this given diagram there are two main components of the model i.e. resource pool (entire available resources) and the resource consumer. Basically the available resources are consumed by the consumer. Therefore a history of resource consumption is maintained in this model. This historical pattern of resource utilization is utilized with the predictive machine learning algorithms for predicting the future possible resource requirements. Based on the predicted resource requirements a decision making function is used to estimate the required resource supply to the consumer. This resource management technique can be utilized in different real world resource assignment problems. In this presented work we are employing this technique into solving irrigation decision making task. This technique will automate the irrigation process and make smart decisions without interference of farm administrator.

But the actually required proactive water management technique for irrigation system needs some additional components for accurate decision making. Therefore an overview of the required proactive irrigation model is demonstrated in figure 2. This diagram is supposed to be an extension of the proactive irrigation model demonstrated in figure 1.

Water storage: according to the design given in figure 1, the water storage is the resource pool. It means the water is consumable resource for the proactive management system. According to the farm size, the water source may be in different form such as ground water source, river or any channel.

Farm: In this current scenario, the farm is consumer of water resource. In this experiment, it assumed the farm is equipped with the sensor devices and we can collect the soil moisture and temperature sensor readings.

Historical crop water requirements: it is a database, which consist of previously collected sensor reading. Additionally, the sensor reading was label with the relevant water treatment. In this experiment, we have used a soil moisture and temperature sensor dataset for experimentation. However, according to the collected literature the irrigation decision can also be influence with the weather conditions. Therefore, a weather dataset is also use with the soil condition dataset.

ML algorithm Training: In this presented work we utilized two different ML algorithm for performing the prediction namely Artificial Neural Network (ANN) and Support Vector regression (SVR). The ANN and support vector machine both are use in a number of such applications for performing the predictive task. The algorithms are train in the following scenario:

1. ANN used for weather prediction and SVM is used for water treatment prediction
2. SVM used for weather prediction and ANN is used for water treatment prediction
3. ANN used for weather prediction and ANN is used for water treatment prediction
4. SVM used for weather prediction and SVM is used for water treatment prediction

Trained ML Model: the above-discussed combinations of prediction algorithms are utilize for prediction of the relevant information. The predicted information is use for combining them to get final decision to enable water supply. In this context, let the weather prediction is denoted as P_w and the water treatment prediction is given by P_t. Now we have two different strategies to combine the prediction as:

Case 1: using the weighted technique, in this technique we are combining the predictive outcomes by using a weight utilizing the both predictions as:

$$W = P_w * w_1 + P_t * w_2$$

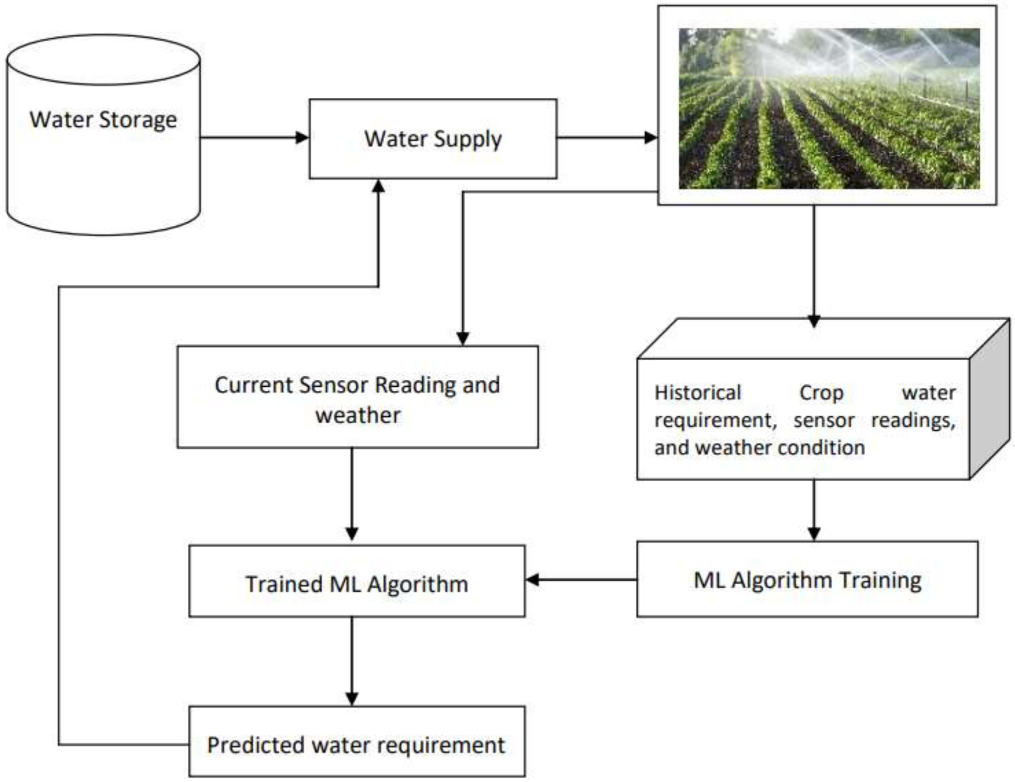


Figure 2: Proposed proactive irrigation management system

Where, the W is combined weight, w_1 and w_2 is the weighting factor and the follows $w_1 + w_2 = 1$. The w_1 and w_2 is selected by the system designer and based on the farm conditions and weather conditions. In this work we assumed w_1 = 0.6 and w_2 = 0.4.

Case 2: combined as the constraint implementation, in this technique the rules had developed to manage the final decisions. In this context, the following rules are developed.

- If next day weather = rainy && water treatment = True
  - Water supply status = wait
- If next day weather = cloudy && water treatment = True
  - Water supply status = wait
- If next day weather = sunny && water treatment = True
  - Water supply status = Enable supply
- If next day weather = sunny && water treatment = False
  - Water supply status = wait

Both the type of training models had utilized for performing training and prediction.

Current sensor reading and weather conditions: Now we can utilize the real and current sensor reading and weather conditions to predict the next day water requirements.

Predicted water requirements: the trained machine learning models are utilize with the sensor reading and weather conditions for predicting next conditions. This predicted next day conditions we map the prediction into the water supply decision. This function has known as mapping function. However, in rule-based method, we need not to apply any additional mapping function, but in weight-based method, we need to design a mapping function. The weight returns a value between zero and one. The value near to the zero has considered as not treatment and value nearer to one requires the water treatment. The weights have mapped into the water treatment decision using the following function.

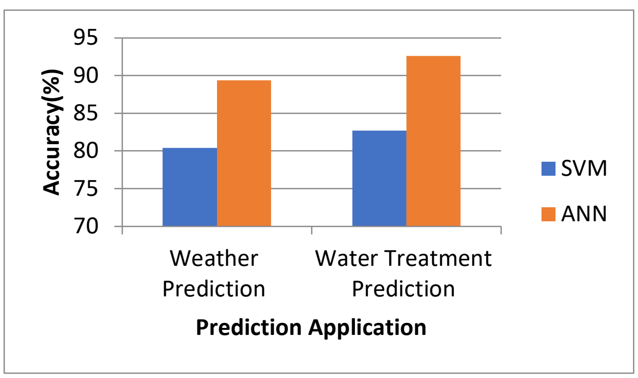
$$f(x) = \begin{cases} if\ W = 0\ or\ W < 0.2 \quad then\ 0 \\ if\ W > 0.2\ and\ W \leq 0.4 \quad then\ 1 \\ if\ W > 0.4\ and\ W \leq 60\ then\ 2 \\ if\ W > 0.6\ and\ W \leq 0.8\ then\ 3 \\ if\ W > 0.8 \quad then\ 4 \end{cases}$$

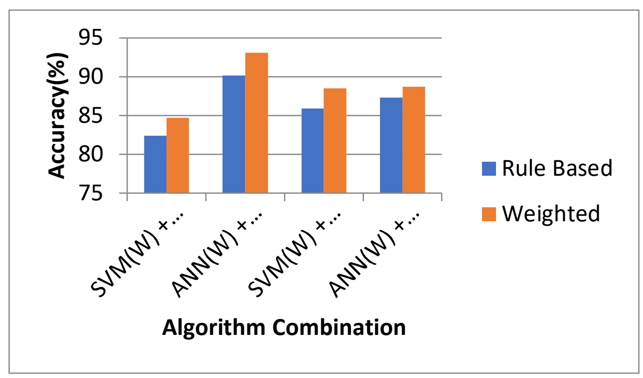
Water supply system: In order to manage the amount of water to be treated the mapping function or rules are used. Additionally the automated water supply system has triggered.

This section discusses the proposed proactive irrigation system for optimizing the need of water in agricultural practice. The next section provides the outcomes of the different experiments performed.

III. RESULTS DISCUSSION

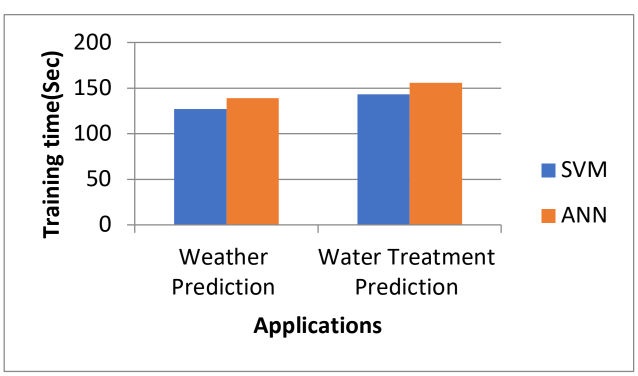
The proposed irrigation system is a resource management based solution. In order to solve this problem we utilized a proactive approach. This approach has based on a machine learning (ML) based technique for performing the prediction in managing the water resources.

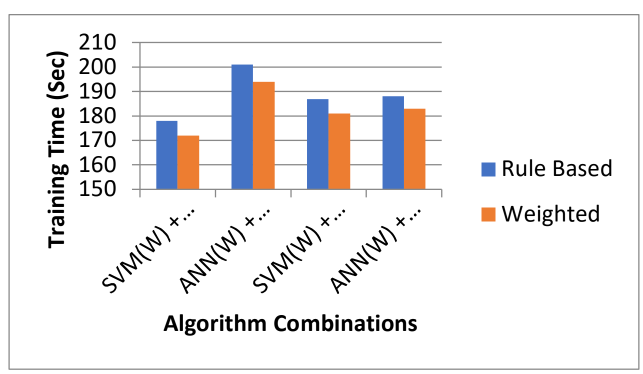




(A)

(B)





(C) (D)

Figure 3: (A) Accuracy of classifiers (B) Accuracy of classifier's combination (C) Training time of classifiers and (D) Training time of classifier's combination

In order to validate the proposed model we utilized two different datasets namely soil moisture and temperature dataset and the weather prediction dataset. In order to classify the events in the given dataset we utilized ANN and SVR classifier. The comparative performance of both the classifiers for both the applications has given in figure 3. The X-axis shows the applications where the ML algorithms had applied, and Y-axis shows accuracy of the classifier in terms of percentage (%). According to the results, the ANN is able to predict more accurately as compared to SVR algorithm in both the cases. Additionally the probability of accurate prediction has increased when we tune the network. Therefore, the ANN algorithm is beneficial for the application.

In addition, the accuracy of classifiers in different combination has also used for validating the water supply enabling and disabling purpose. In this context, we utilized two different approaches namely weight based technique and rule based technique. The performance of the classifiers with both the techniques has given in figure 3. The X-axis consists of the different combinations of ML algorithm used for prediction, and Y-axis shows the accuracy obtained in both the cases according to the combination of ML algorithms. According to the experimental results, the weighted algorithm will able to make precise decision as compared to rule-based method. In addition, the ANN based classification technique outperforms in all the cases examined.

The training time of classifiers for both the applications i.e. weather prediction and water treatment prediction has demonstrated in figure 3. The training time has measured in terms of seconds (sec) and given in Y-axis. Additionally, the X-axis shows the applications where the ML algorithm had applied. Based on the experimental performance we can say the ANN is computationally expensive as compared to SVR based approach. However, the ANN is slight expensive therefore it is acceptable for utilizing in real application.

Next, we evaluated the methods of combined decision prediction. In this context weight based method and rule based method is evaluated for obtaining the time efficiency. The figure 5.6 shows the training time for different combination of ML algorithms. According to the experimental measurements, the weight-based technique is efficient as compared to rule-based technique. In order to describe the results in figure 5.6, the X-axis shows the combinations of the ML algorithms and the Y-axis shows the required training time for the relevant algorithms. Additionally in all the experiment, the ANN based algorithm combination for both the applications weather prediction and water treatment prediction shows higher amount of time consumed as compared to other implemented ML algorithm's combination.

IV. CONCLUSIONS

The agricultural practice required a significant amount of water. Additionally due to different kinds of fertilizers and pesticide, the water get polluted and not utilizable in daily usages. Therefore, we need to incorporate the methods and techniques that will reduce the water requirement without affecting the crop production. This paper provides a new technique to improve the irrigation technology. In this technique, soil moisture, temperature and weather conditions are use to make decision about the irrigation of crop automatically. In this context, first the relationship among the weather, temperature and moisture has measured, and then use with a mapping function for the water treatment decision. An artificial neural network and SVR has trained for making prediction and support the decision making process. The different combination of ML algorithms had applied and the performance of predictive model has recorded. According to the results, ANN based techniques are providing better performance than the SVR based approach in most of the scenarios. Therefore, the proposed concept of irrigation automation is acceptable for the utilization. In near future the proposed work will be extending to incorporate the following modifications:

1. Apply the proposed simulation concept to real world application
2. Incorporate the mobile irrigation model to reduce need of infrastructure cost and water requirement
3. Research on IoT enabled devices to monitor the soil conditions and making decisions.

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