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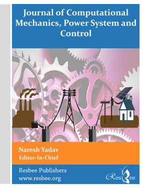

Hybrid Grasshopper Optimization Algorithm and Genetic Algorithm for Optimal Water Control in Sugarcane Crops

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Abstract: The Internet of Things (IoT) inventive services lead to the model of complicated systems by exploiting heterogeneous technologies. IoT pretense combines networks to present even services to people. In sustainable sugarcane crop production, irrigation plays an important role in regions that undergo a scarcity of water. In agriculture, the efficient exploitation of water is an important constraint because of raising the water demand as well as the extreme need to improve productivity. This work presents a Hybrid Grasshopper Optimization Algorithm and Genetic Algorithm based Deep convolution neural network named (Hybrid GOA and GA-DeepCNN) approach to provide the best water control in sugarcane crops. Moreover, the push-based approach, as well as the transformation of a log, is used to make the data appropriate for processing. Additionally, apriori approach is used to select the effectual feature from an enormous set of features acclimatizing a feature score. In order to maximize the classifier accuracy, the apriori approach is aided. In order to compute the watering quantity, a feature score is recently formulated to recognize the capable features. By exploiting the Deep CNN the water controlling stage is carried out and that is trained using the Hybrid GOA and GA optimization approach. The developed model performs better than the conventional models with maximum accuracy, sensitivity as well as specificity.

Keywords: Crop production, Classifier, DCNN, IoT, Networks, Optimization Algorithm

Nomenclature

Abbreviations	Descriptions
WSNs	Wireless Sensor Networks
IoT	Internet of Things
GOA	Grasshopper Optimization Algorithm
EC	Edge Computing
ML	Machine Learning
GA	Genetic Algorithm
UAVs	Unmanned Aerial Vehicles
NN	Neural network
QoS	Quality of Service
ICT	Information and Communications Technologies
DLT	Distributed Ledger Technologies
SVM	Support vector machine
UAVs	Unmanned Aerial Vehicles
DBN	Deep Belief Network
BDA	Big Data Analytics
TS	Tournament Selection
PSO	Particle Swarm Optimization

1. Introduction

Agriculture is experiencing a 4th revolution during the past few years, by combining the integration of ICT with conventional farming practices. Technology, such as UAVs, ML Remote Sensing, IoT, as well as BDA is chiefly shown potential as well as they can present a new come through in agricultural practices. An extensive range of agricultural parameters in smart farming can be monitored to enhance the yields of crops, minimize the costs as well as optimize the process inputs like growth status, environmental

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circumstances, the status of soil, irrigation water, pest as well as fertilizers, management of weed, as well as production of greenhouse environments [1].

Farming is considered a green technology method because it minimizes the ecological footprint of conventional farming. Inaccurate agriculture, the least exploitation of fertilizers, smart irrigation as well as pesticides in agricultural crops can furthermore minimize the leaching issues as well as emissions, and the climate change impact. In contemporary wireless communications, the IoT is represented as the major revolutionary technology. The fundamental idea is the communication among a diversity of objects or physical things exploiting particular addressing models to be linked to the Internet [2].

In several vertical markets such as healthcare, industry transportation, vehicles, agriculture as well as smart homes IoT technology is exploited [4]. IoT devices present helpful information on an extensive range of physical parameters to improve the cultivation practices in an agricultural environment. In IoT technology, the WSN's role is of supreme significance as a large amount of IoT applications in several markets are on basis of wireless data transmissions [3].

In order to optimize irrigation water usage, various approaches are formulated to raise crop production. A technique is exploited by taking into consideration of weekly time steps to balance water for the planning of the irrigation [5]. Moreover, an empirical yield approach was formulated by exploiting the weather data in order to recognize the best allocation of water among diverse phases of crop yield. To explore the diverse status of crop water to activate irrigation to maximize the yield of sugarcane the complicated experimentation approach is changed. This optimization approach ascertains the optimal option from frequent options as well as applies the chosen option to increase crop production. The meta-heuristic approaches such as GA as well as PSO were exploited to balance the water by exploiting the yield response technique to ascertain the best irrigation schedules. In some works, an automatic irrigation approach was formulated by exploiting the DSSAT crop modeling system by taking into consideration of three heuristic optimization approaches to optimize the irrigation as well as maximize the crop yield. The method plans irrigation events on basis of the different water thresholds [5].

The main aim of the research is to attain the best water control scheme in an IoT network for that the adopted hybrid GOA-GA-based DNN optimization model is used. The main purpose of this paper is water quantity tracking by exploiting the sugarcane features set. At first, every IoT node obtains particular information such as temperature, humidity, soil moisture, sugarcane age, and sugarcane size besides the parameters of the dataset. The attained data comprises numerous noisy as well as extraneous data which might reduce the complete approach performance. Therefore, the log transformation, as well as the push-based approach, is used to remove the noisy as well as inappropriate data by bounding the data. Moreover, to make the data appropriate the user-defined threshold is used in order to extract the important features. Apriori approach is used to select effectual features by using the recently formulated feature score. Moreover, tracking the water controls Deep CNN is used by exploiting the important features which are obtained from the feature score. At last, an optimization Hybrid GOA and GA approach is used to train the DeepCNN so that the parameters of the model are learned optimally.

2. Literature Review

In 2020, Redmond R. Shamshiri et al [1], developed an IoT application for technique-based microclimate parameters assessment inside two greenhouse crop production systems. Thus, the main contributions were to extend such a reassuring ratio technique, as well as a custom-built wireless sensor for data combination to estimate as well as evaluate the parameters of microclimate inside two diverse tropical greenhouses before the definite cultivation of tomato.

In 2020, Amaya Diaz Juan Carlos et al [2], propose the intensification of resources that farmers had for disease crops management as well as a pest as well as diseases in a digital manner by exploiting the IoT via the prototype development. It can attain significant variables information in a strawberry crop like Relative Humidity, temperature, as well as pH. In real-time, data were processed as well as attained using the protocols. The devices permit controlling the information of diverse variables via communication amid the sensors. This paper proposes one of the important strawberry characteristics exploiting the IoT system data collection.

In 2019, Ricardo S. Alonso et al [3], focused on the dairy industry, and its requirement to acclimatize to the present market by attractive additional resource competent, transparent environment-responsive, and safe. The EC, IoT, as well as DLT, were all vital to the accomplishment of those enhancements since they permit the digitization of all segments of the value chain, presenting comprehensive information to the customer on the concluding product as well as assuring its quality as well as security. DLT and IoT facilitate traceability as well as resource monitoring in the value chain, permitting producers to optimize processes, present derivation of manufacture, and assurance of its quality to customers in Smart Farming environments. EC controls the IoT devices that generate the Big Data by processing them at the network edge, permitting for the accomplishment of the services with minimum response times, as well as superior QoS and security in evaluation with a centralized cloud.

In 2021, Xianhai Guo [4], worked on IoT horticulture and remote sensor functions. Convene with the inventive farming regular practice, face confronts to look ahead. An inaccurate agricultural application can access record the sensor like crop circumstances, soil preparations, insects, water systems, and irrigation examining from the planting to harvesting phase via the crushing, harvesting and transport inventive manners to aid the growers turns out to be highly obvious. Additionally, this technique was highly taken into consideration in crop scouting as well as important applications like exploiting an automatic to raise the yields of crops. In some scenarios, it may develop diverse things as well as optimal techniques on the basis of the agriculture phase.

In 2020, Achilles D. Boursianis et al[5], performed a model on IoT and UAV technology which was exploited in agriculture. The most important aim of the IoT technology was described such as IoT sensor types, intelligent sensors, protocols as well as networks, exploited in agriculture and IoT applications as well as answers in smart farming. In addition, the UAV technology's role in smart agriculture was presented by exploiting UAV applications in several cases such as fertilization, irrigation, pesticide use, monitoring of plant growth, weed management, as well as management of crop disease. Further, the UAV systems utilization in the complicated agricultural environment was estimated.

3. System Model

The IoT comprises diverse objects such as smart devices that are linked with each other in order to exchange the collected data via the network [8]. In the IoT, numerous smart devices are resource-constrained that impose communication as well as processing abilities to exchange data. In the IoT system model, various nodes in the network are detached to transmit data packets to BS by exploiting capable paths. IoT is marked among diverse minimum power networking protocols, such as ZigBee, Bluetooth, as well as ZWave. For domain-specific applications with exclusive characteristics protocols are maintained [7, 9]. Nevertheless, the smart objects are resource-constrained as well as energy; therefore, the gateway must be responsible for management [13].

Let an IoT network with g count of nodes as, $G = \{G_1, G_2, \ldots, G_b, \ldots, G_g\}$ relies on the coverage area F. Every IoT node b obtains information associated with sugarcane plants is taken into consideration of particular metrics, like temperature, soil moisture, humidity, size of sugarcane, as well as the age of sugarcane all along with the dataset metrics. In the agriculture domain, IoT is very helpful in order to enhance production because the IoT nodes are used to monitor the acidity variables, soil temperature as well as other variables. Additionally, the IoT increases the production level as well as reduces the physical work as well as time, and aids to formulate the farming very effectual. In addition, the IoT is taken into consideration as a smart irrigation technique that evades the practice of water as well as minimizes water wastage which can be exploited in enormous regions. IoT is considered an effective technique wherein the labor deficiency issue might happen. Hence, it is very important to model the best water control approach by exploiting the IoT network.

4. Adopted Model for Optimal Watering Control

An eventual aspire of paper is to model the technique for the best watering control in sugarcane plant on basis of monitored metrics like temperature, humidity, moisture of soil, size of sugarcane as well as the age of sugarcane as well as other metrics such as leaf length, thickness, and etc. At first, the aforesaid information with the dataset metrics is fed to the best watering control. By exploiting the push-based approach as well as log transformation the gathered data is pre-processed so that the data turns out to be ineffective for the watering control. Subsequently, pre-processed data is fed to the feature selection component in that the apriori approach is used for feature selection. Subsequently, chosen features are subjected to the optimal watering control tracking component of the sugarcane plant, wherein DeepCNN is used to enable the effectual watering control. Therefore, the water control component is performed by exploiting the DeepCNN that is trained by exploiting the adopted optimization approach.

Fig. 1 demonstrates the architecture model of the Hybrid GOA-GA-based DeepCNN for optimal watering control in an IoT network.

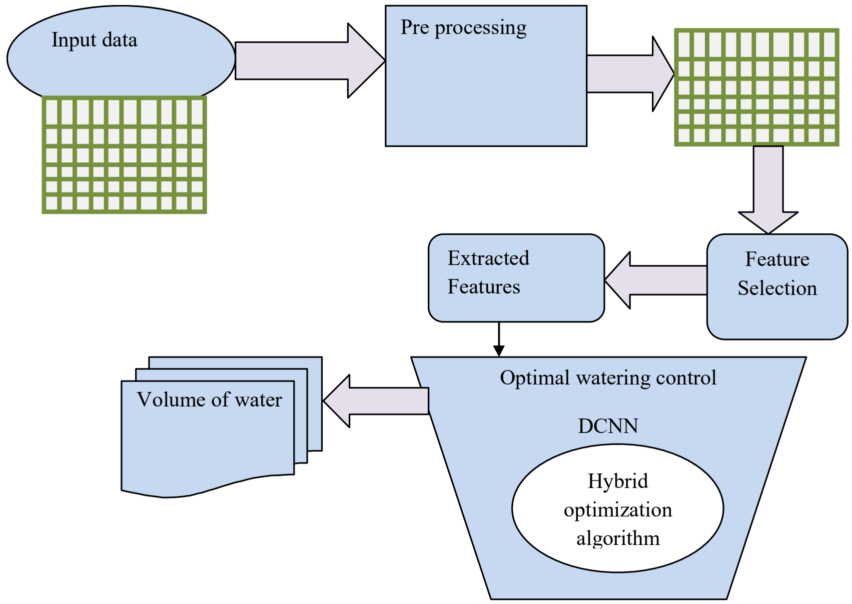


Fig.1. *Architectural model of the proposed Hybrid GOA-GA based DCNN for optimal water control*

Let b^{th} IoT node comprises information associated with the sugarcane plant by taking into consideration of the specific metrics and dataset parameters. These attributes are fed to the pre-processing stage to remove the inappropriate data comprised in the entire dataset.

4.1. Sugarcane Data Pre-processing

The pre-processing is taken into consideration as an important model to systematize thousand of data in an even way to present the effectual outcomes. The pre-processing aids to define the data processing to attain superior indications. The database comprises irrelevant data that affects the feature selection process. Therefore, the pre-processing turns out to be a significant process to eliminate the contradictory data from the database. Moreover, by exploiting the push-based approach as well as log transformation the pre-processing is performed.

a. Log transformation

The data transformation is the process that is performed by using a mathematical formulation as well as implementing it on data. Moreover, a general transformation is used on data is log transformation. In this approach, every data is put back within a log function where the log base is set by a forecaster that might be two or ten. To compress enormous data process is exploited.

For example, if there have enormous data afterward, lesser values are acquired inundated by enormous values. In addition, using a log on every data makes easy apparition to be very clear. In addition, the log transformation de-highlights the outliers as well as allows attaining the best distribution. It is presumed by exploiting the data log possesses the capability to restore the data symmetry. The log transformation imposes the capability to verify data on basis of the statistical analysis to light up hidden data. Therefore, the log transformation is precious to make data patterns highly interpretable.

b. Push-based approach

To pre-process data push-based approach is used to remove the superfluous data. In this approach, 2 steps are used to make the data highly important to compute the features that initial one is data bounding and the next one is to eradicate the inappropriate data. Each data mean is calculated in data bounding where each data indicates the particular attributes such as stalk length, leaf length and etc. Meantime, the threshold is set that is user-defined. The data mean is augmented as well as subtracted with a threshold as well as values attained among the ranges of two values are exploited to choose data. Likewise, values are calculated for every data attribute. The value that relies upon ranges by taking into consideration every data attribute is concerned as helpful data to perform the feature selection. Moreover, the mean values are exploited to fill missing values. The residual data are taken into consideration of inappropriate or noisy that should be evaded to enhance the crop production.

4.2. Apriori Approach for Feature Selection

In pre-processing, the feature selection is a significant model used to mine important data. The technique is used to eradicate the noisy features from enormous datasets to model the robust learning approaches. The enormous number of features reasons the sluggish down in the learning procedure as well as increases the learned classifier risk that might tend to overfit data which reasons the mystification. Hence, the important feature selection can bring high advantages to real applications.

Apriori approach [10] is association rules mining approach that initiates the exploitation of aid-based pruning to select optimal features. The feature selection is an approach used to improve association rule mining performance. The initial step is to ascertain the adequate feature by exploiting the aided as well as confidence values. The aid is used to ascertain rule applicability in a presented dataset as well as confidence ascertains how frequently feature happens in data. Moreover, apriori approach is exploited to ascertain important features by exploiting the feature score that is taken into consideration in the databases by reducing the redundant search.

Let υ signifies each feature index which varies from 1 to n, D_υ indicate complete features of sugarcane crop as well as H_υ denote a set of frequent features. By exploiting the features, the new features are ascertained in the preceding iteration for each iteration. Each feature support is numbered as well as examined regarding the threshold.

The subsequent step is to model association rules that fulfill user-defined least confidence by exploiting the adequate item sets.

Let the frequent item set as H_υ, and it is stated in eq. (1). By exploiting the generated feature, aforesaid association rules, wherein the rule is generated are taken into consideration features by calculating the feature score. Eq. (2) states feature score.

$$H_\upsilon = \{I_1, I_2, \ldots, I_\ell, \ldots, I_\upsilon\} \tag{1}$$

$$\text{Feature Score} = \left(\frac{1}{K} \sum_{i=1}^{K} \frac{T_i^f}{T_i^K} \times M \right) \tag{2}$$

In Eq. (2), M signifies mean of support in i^{th} length series T_i^f signifies rules covered by f_i, K signifies the length of frequent features, and T_i^K signifies the total rules. Eq. (3) states the selected features and indicated as a feature vector and it is represented as R, wherein R_w signifies w^{th} feature as well as j signifies total features.

$$R = \{R_1, R_2,, R_w,, R_j\} \tag{3}$$

4.3. Watering Control Tracking

Here, the adopted optimization model based on Deep CNN is used to track optimal water control as well as by exploiting the feature vector the tracking is improved. By exploiting the Deep CNN, The features are proposed for the classification as well as the optimization model is exploited to train the classifier. The major objective of the adopted model is to identify the water quantity which needs for the sugarcane crops cultivation. The major objective of Deep CNN training is to compute the best weights in the Deep CNN to track the best water control needed for sugarcane crops.

a. DeepCNN model

The fundamental model of the Deep CNN [11] is exploited that comprises the "convolutional (Conv) layers, pooling (POOL) layers, as well as fully Connected (FC) layers", wherein every layer is in charge to perform an exclusive task. The main aim of the conv layers is to outline feature maps by exploiting features as well as feature maps are furthermore sampled down to attain pool layers that are the next layer in Deep CNN. Finally, the FC layer tends to track the procedure. In DeepCNN by exploiting a huge count of Conv layers the classification accuracy is enhanced.

Convolutional layers:

To track the water, the conv layer is used by exploiting the feature vector attained from obtained data. Subsequently, the consequence is fed to the nonlinear activation function to easiness complicated functional mapping among the input as well as reply variables. In the convolution layer, the input is a feature vector R attained as an outcome of feature selection as well as the count of conv layers in Deep

CNN is stated in eq. (4), wherein, T_u signifies u^{th} conv layer in Deep CNN as well as v signifies total count of conv layers in Deep CNN.

$$T = \{T_1, T_2, ..., T_u, ..., T_v\} \tag{4}$$

Eq. (5) states the units positioned at (m,n) deriving the outcome, wherein, $\left(T_p^{u-1}\right)_{m+z,r+s}$ signifies fixed feature maps, $*$ signifies conv operator that set up tracking from outcomes attained from neighboring conv layers, and W_l^{p-1} signifies total count of feature maps, as well as $\left(Y_{f,p}^{u}\right)_{z,s}$ signifies weights which are trained by exploiting optimization model.

$$\left(T_f^u\right)_{m,n} = \left(J_f^u\right)_{m,n} + \sum_{p=1}^{W_l^{p-1}} \sum_{z=-r_l^u}^{r_l^u} \sum_{s=-r_2^u}^{r_2^u} \left(Y_{f,p}^u\right)_{z,s} * \left(T_p^{u-1}\right)_{m+z,r+s} \tag{5}$$

POOL layer and ReLU: ReLU represents the activation function to assure the competence and ease as well as consequence of the ReLU layer. The outcome from ReLU layer while subjected to feature maps and is stated in eq. (6), $\text{fun}(\ )$ signifies activation function in u^{th} layer.

$$T_f^u = \text{fun}\left(T_f^{u-1}\right) \tag{6}$$

Fully connected layers: Here, the input is the data generated from the conv layer as well as the pooling layer and that is used to track the water control. Eq. (7) represents the output produced from the fully connected layer, $V_{f,p,m,n}^u$ signifies weight linking (m,n) in p^{th} feature map of layer $u-1$ and f^{th} unit in the layer u. Here, the proposed optimization algorithm is exploited to tune weights optimally.

$$S_f^u = Z\left(a_f^u\right) \text{with } a_f^u = \sum_{p=1}^{W_1^{p-1}} \sum_{m=1}^{W_2^{p-1}} \sum_{n=1}^{W_3^{p-1}} \left(V_{f,p,m,n}^u\right) . \left(T_f^{u-1}\right)_{m,n} \tag{7}$$

b. Training of DeepCNN

Here, the adopted model is used to tune weights optimally for Deep CNN to attain feature maps as well as, to enhance classification accurateness when tracking watering control.

Proposed Hybrid GOA and GA algorithm [6] The adopted model exploits both the advantages of GOA as well as GA approaches [6]. It integrates the exploitation ability of GA as well as the exploration ability of the GOA, wherein GA operators exploit the mutation as well as cross over that stop developed technique from falling to local optimal while GOA process uses the convergence as well as search process to attain a global solution. Here, arbitrary solutions populations are initialized.

Step 1: (Initialization): In d dimensions, a population of agents is initialized with arbitrary positions in search space as well as set parameters of GA and GOA.

The acquired fitness function is estimated in d variables for each agent. Ascertain target position T as the position of the optimal initial agent.

Step 2: (GOA is employed to travel in Search Space: --The location of each agent is updated using eq. (8), where, ub_d and lb_d represents the upper and lower dimension, $\hat{T}_d$ represents the value of d^{th} dimension in the target.

$$Y_i = c\left(\sum_{\substack{j=1 \\ j\neq i}}^{N} c\frac{ub_d - lb_d}{2} s\left(| y_j^d - y_i^d |\right)\frac{y_j - y_i}{d_{ij}}\right) + \hat{T}_d \qquad \forall i = 1, \ldots\ldots\ldots\ldots, N_{grasshoppers} \tag{8}$$

$$s\left(| y_j^d - y_i^d |\right) = fe^{\frac{-\left(|y_j^d - y_i^d|\right)}{l}} - e^{-\left(|y_j^d - y_i^d|\right)}, \ d_{ij} = | x_j - x_i |$$

Step 3 (Evolution using GA): *Selection*: In the adopted model, TS is exploited; wherein a count Tour of agents is preferred arbitrarily from the population as well as an optimal agent from this group is elected as a parent. This process is continued as recurrently as agents must be chosen.

Crossover: Two agents, $A = [a_1, b_1]$ as well as $A = [a_2, b_2]$ are chosen as parents using TS. Presume a is crossover point for a particular A as well as B, as well as a-values in offsprings are ascertained using:

$$a_{new1} = (1-\gamma)a_1 + \gamma a_2, \ a_{new2} = (1-\gamma)a_2 + \gamma a_2 \tag{9}$$

wherein γ represents an arbitrary count among 0 as well as 1. The residual parameter (b in this scenario) is placed straight from every parent, consequently, new offsprings are:

$$\text{offspring}_l = \left[\text{anew}_l, b_l\right], \; u \tag{10}$$

Mutation: Every agent is mutated in a string $\gamma_i \in [a_i, b_i]$ with mutation probability p_m by augmenting together small arbitrary values on basis of the formulation stated below:

$$Y_i = \begin{cases} Y_i + \Delta(t, b_i - Y_i) \text{ if } \delta = 0 \\ Y_i - \Delta(t, b_i - a_i) \text{ if } \delta = 1 \end{cases}$$
$$\Delta(t, y) = y\left[1 - r^{\left(1 - t/T\right)^{\beta}}\right] \tag{11}$$

wherein r indicates an arbitrary number r ∈ [0, 1] as well as β indicates a positive constant chosen arbitrarily.

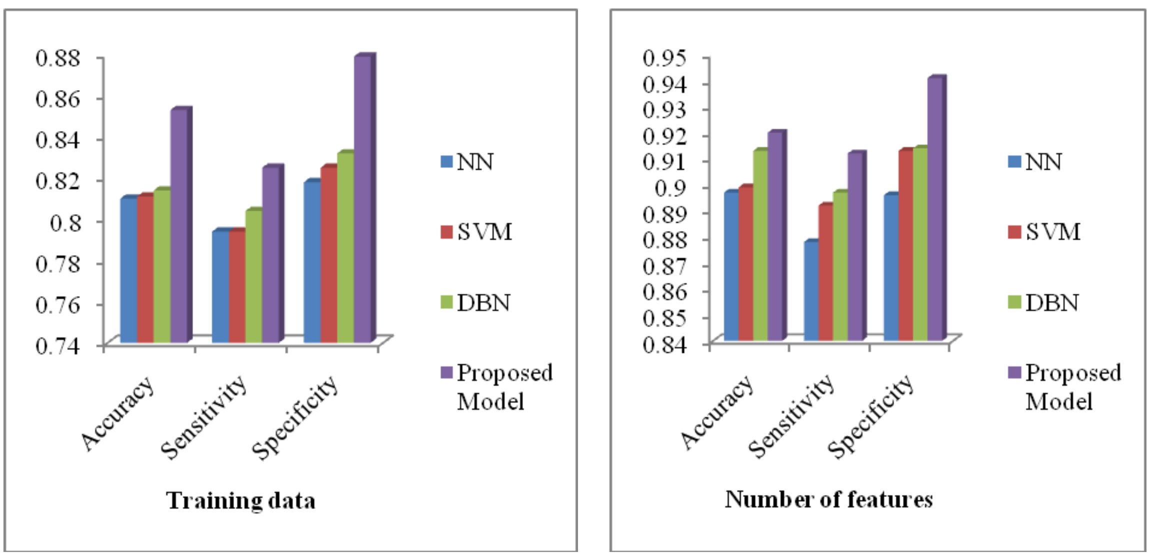
- Elitist scheme: The list of optimal agents directly entering into a new set of agents is elitism.
- Estimation: The acquired fitness function is calculated in d variables for each agent.
- Updating: Update target location T as the best agent location establish hitherto.

Step 4 (Termination criterion): If the supreme number of generations is achieved or agents meet, the adopted model will be halted. Finally, target location T is represented as the optimal solution.

5. Result and Analysis

The evaluation of the adopted as well as the existing techniques was discussed in this section via the sugarcane dataset by exploiting the accuracy, sensitivity as well as specificity. Here, the evaluation was carried out by deviating training data and also by deviating the count of features. The approach used for the comparison such as "NN [12], SVM, DBN algorithm".

Fig 2 demonstrates the analysis of proposed and conventional models on the basis of training data as well as a number of features and on the basis of the parameters like "accuracy, sensitivity, and specificity". Here, analysis reveals that the proposed attained maximum accuracy, sensitivity as well as specificity correspondingly.



(a) (b)

Fig.2. *Performance analysis of the proposed and conventional models (a) Training data (b) Number of features*

6. Conclusion

The main aim of this work is to present an optimization-based deep learning approach in order to track water control in sugarcane crops. Moreover, the adopted model was used to train the DeepCNN to derive the optimal weights so that approach parameters were learned optimally. Moreover, every IoT node obtains particular information like temperature, humidity, soil moisture, and sugarcane age as well as sugarcane size besides the parameters of the dataset to estimate the water requirement volume to cultivate the sugarcane crops. The main objective was to extract the important features from the features set by exploiting a recently formulated feature score which comprises rules ascertained using the apriori approach. In addition, DeepCNN was used to track the water quantity practice by taking into consideration of the most important features which was produced from the feature score. At last, a Hybrid GOA and GA optimization approach was exploited to train the DeepCNN so that the parameters model was learned optimally. The adopted Hybrid GOA and GA-based Deep CNN techniques were modeled in order to validate the effectual accuracy via the efficient water tracking by taking into consideration of the IoT network.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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