# Performance Prediction of Higher Education Institutions using Artificial Neural Network

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*Abstract*— **Assessing the academic excellence of the institution in terms of quality education should motivate the Higher Education InstitutionsPredicting Higher Education Institutions academic performance with a high accuracy facilitates the quality of the institute in terms of education, infrastructure, research, teaching & learning, admission decisions and also enhances funding services like UGC grants, RUSA grants, financial aid etc at educational institutions. Predicting Higher Education Institutions academic performance based on quantity, quality, relevance and excellence of academic programmes offered of higher education has long been an important research topic. Academic performance has been identified by a set of several criteria to serve as the basis of its assessment procedures. To extract some meaningful information from these large volumes of data, academic organizations have to mine the data. In this Paper, an approach based on the artificial neural network (ANN) with Cuckoo Optimization Algorithm (COA) is proposed to predict and assess the academic excellence of the Higher Education Institutions.**

***Keywords***—**Higher Education Institutions, assessment, academic performance, artificial neural network, Ant Colony Optimization, Data Mining, Machine learning.**

## I. INTRODUCTION

Education plays an important responsibility task in the progress of any country. Educationalists are expecting excellent quality on the excellence of academic programmes offered of higher education. Educational Data Mining [EDM] is a kind of mining [9][10] educational data from a massive educational database, in which valuable information and patterns can be mined to predict the Academic Institution performance. Data mining [3], Artificial Intelligence, Deep Learning and machine learning are applied on EDM data to derive knowledge from educational atmosphere. Currently, accessing Higher Education Institutions is in demand and gaining more consideration because of increase in the educational information of e-learning systems, online courses and even progressing traditional education.

If the performances of Higher Education Institutions are predicted well in advance, then it can upkeep or improve the quality of education, student level activities, and assists in improving the performances in universities and educational institutes [4]. Researchers concluded that some Deep learning applications can be applied in predicting Student's Performance [5], Academician's Performance and Educational Institutions Performance too. The artificial neural network (ANN)[1] is a combination of computational and statistical technique that has been a successfully applied in different field of prediction. In this paper, ANN with the Cuckoo Optimization Algorithm (COA) [8] is used to predict the academic excellence of the institution in terms of quality educations.

Next section II deals with brief review of the related work and then in the section III, the suggested techniques and approaches used to predict the academic excellence of the institution is explained. In Section IV, detailed implementation techniques and issues are analyzed and followed by Conclusion and expected work in the future is presented in Section V.

## II. RELATED WORK

Artificial Neural Networks are the biological computational models inspired by the human being brain. Many of the recent developments have been make use of Artificial Neural Networks in the field of Artificial Intelligence, including Voice Recognition, Image Recognition, pattern recognition, fault diagnosis, forecasting and prediction, and Robotics using Artificial Neural Networks. A multilayer perception neural network is utilized by Kanakana and Olanrewaju [7] to predict student performance. The average point scores of grade 12 students are used as inputs and the first year college results is given as output. This research proved that an ANN based model is competent to predict student performance in the first semester with high accuracy. To predict the students' final achievement, a multiple feed-forward neural network was proposed in the above said model.

Vinod Kumar Pal, Vimal Kamlesh Kumar Bhatt used an ANN based model [15] to predict the performance of a student being considered for admission into the university for higher studies. The research indicated that the ANN model is able to accurately predict the performance of more than 70% of the ultimate students. The above mentioned researches revealed the immense achievement of neural networks in the prediction of student academic performance. Data mining methods are also very much helpful in predicting the performance of any problem [14].

Training algorithms play a key role in enhancing the quality of ANNs. When a neural network is designed to predict the performance of a particular application, it must be trained before being utilized to classify the test data. The aim of the training the data is to reduce a cost function defined as the mean squared error or sum squared error between its predicted and targeted outputs by regulating the value of weightages and biases. Deciding the Efficient training algorithm has always been a challenging subject in the performance prediction of a problem. An admired approach used in the training phase of the data set is back-propagation learning; however, researchers have pointed out that some commonly used learning algorithms have disadvantages like not guaranteed to find the minimum of the error function. Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) [13] have been proposed for the purpose of training neural networks by some of the researchers. But all these algorithms are having its own restrictions in predicting the performance of problems. Currently, two meta-heuristic algorithms [6] encouraged by the lifestyle of cuckoo birds were developed for solving optimization problems. Through some standard studies, these two algorithms have been proven to be powerful meta-heuristic ones. Cuckoo Search (CS), proposed by Yang and Deb, was inspired by the particular egg laying and breeding characteristics of the cuckoo bird. The Cuckoo Optimization Algorithm (COA), developed by Rajabioun [11] is the algorithm used of Optimization problem. When compared the COA with typical versions of PSO and GA, it is predicted that the COA has better-quality in rapid convergence and inclusive optimal attainment of the performance.

Our aim is to use the efficient training algorithm for constructing a neural network that accurately predicts Higher Education Institutions academic performance. However, as far as we are aware, not much research on predicting the Higher Education Institutions academic performance takes advantage of ANN with the heuristic algorithm like COA.

## III. Proposed Methods

Higher Education Institution should know its strengths, weaknesses, and opportunities through an informed review process based on standard body. Funding agencies look for objective data of the institution for funding. Institutions should initiate innovative and modern methods of pedagogy.Performance prediction based on standard body gives new sense of direction and identity for institutions. The society look for reliable information on quality education offered and also Employers look for reliable information on the quality of education offered to the prospective recruits. Intra and inter-institutional interactions can also be enhanced based on the Higher EducationInstitution's performance review.

### *A. Artificial Neural Network*

This section represents the artificial neural network model that is to be used for the prediction of Higher Education Institution's academic performance [12]. ANN is considered as one of the best straightforward statistical models to improve the existing data analysis technologies. Though there are statistical models which have been available, they have not achieved theoretical successful prediction chances. It is always expected that there can be a room for improvement of ANN and the prediction model as the days and technologies progress. This leads to the new approach proposed in this work for accomplishing a successful prediction of a Higher Education Institutions academic performance.

An artificial neural network (ANN) has two basic elements, namely, neuron and link. A neuron is a processing element and a link is used to attach one neuron with another. Each link has its own weightages. Each neuron obtains activation from other neurons, processes the information with better optimization, and produces an output. Neurons are categorized into a series of three different layers, called input, hidden layers and output layers, respectively.

The input layer is an information layer that presents data to the network. The hidden layer job is to process the input information acquired from its previous layer. Subsequently it is the layer which is responsible for extracting the required attributes from the input data.They are not discernible to the outside the neural network systems and are "private" to the neural network. Zero or more number of hidden layers is allowed in a neural network system design. But only one hidden layer is enough for the large majority of problems.

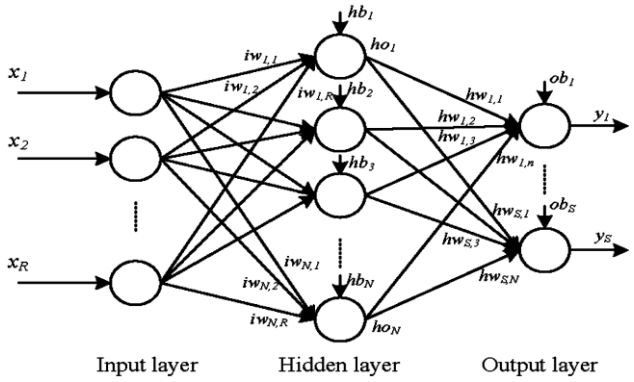
The output layer is responsible for producing the final result to a given input. It is better to design only one output layer in a neural network. The output layer takes information from the hidden layers after performing the calculations based on its neurons weightages and biases and then the output is calculated. The activation coming into a neuron from other neurons is multiplied by the weightages on the links over which it spreads, and then is added together with other incoming activations. To provide a good non-linear relationship, a multi-layer feed-forward network can be used for a given set of data. Literature shows that a feed-forward network, even with only one hidden layer can be approximate for any problem. As a result, a feed-forward network is a best approach for the nonlinear problems.

A feed-forward network is shown in Figure 1 with three layers where in R indicate the numbers of input variable, and N as well as *S* are the numbers of hidden neurons, and output variable respectively; the input and hidden weightages are *iw* and *hw* , respectively; the bias vectors of the hidden and output layers are *hb* and *ob*, respectively; *x* is the input vector of the network; *ho* is the output vector of the hidden layer; and *y* is used to symbolize the output vector of the network. *F* is used to represent the activation function. The neural network based on the input vector, hidden weightages, the bias vectors and output vector can be expressed through the following equations:

$$\boldsymbol{ho_i = f(\sum_{j=0}^{R} i\, w_{i,j} x_j + hb_i), for\ i = 1,..,N}$$

$$y_i = f(\sum_{k=0}^{N} h\, w_{i,k} ho_k + ob_i), for\ i = 1,..,S$$

Fig. 1 A feed-forward network with three layers




In the ANN design, it is essential to decide the number of layers and number of neurons in the hidden layers. The larger the number of hidden layers and nodes makes more complicated network. It performs well on information comprised in the training dataset, but may not perform well on account of testing dataset. When network training is initiated, the iterative process of presenting the training data set to the network's input continues until a given termination condition is satisfied. Some of the termination condition are sum-squared error [SSE] and mean squared error [MSE].

*B. Cuckoo Optimization Algorithm*

Cuckoo Optimization Algorithm (COA) is one of recent development practice that was introduced and presented by Rajabioun[11] . The basic idea of this algorithm was a cuckoos individual egg laying and breeding style. The algorithm starts with an initial cuckoo population. Initially, the cuckoos lay eggs in the host bird's nest. Some of these laid eggs are more alike to the eggs of host birds and thus they have the chance to grow up. The not alike eggs are determined and are killed by host birds. The suitability of the nests in the area is determined through the number of grown eggs reveal. So the task of COA is to discover better locality in which more eggs can stay alive.

The Pseudo code for cuckoo optimization algorithm is given as follows [2].

1. Initialize cuckoo habitats with random points
2. Define ELR [Egg Laying Radius (ELR)] for each cuckoo using the given formulae.

$$\mathbf{ELR} = \alpha * \frac{\mathbf{No\ of\ current\ cuckoo's\ eggs}}{\mathbf{Total\ number\ of\ eggs}} * (Var_{hi} - Var_{low})$$

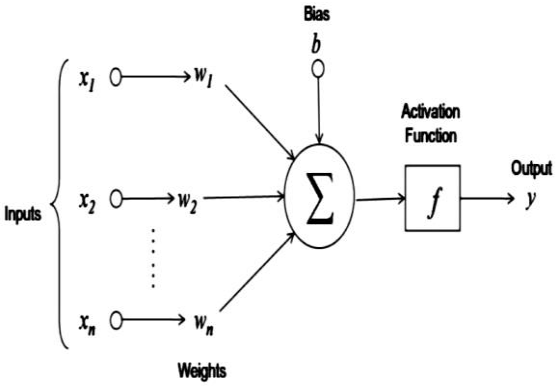
Where α is an integer to handle the maximum value of ELR, and $var_{hi}$ and $var_{low}$ are the upper limit and lower limit for variables, respectively.

3. Let the Cuckoo lays their eggs inside the cuckoo's corresponding ELR to nest of host bird.
4. The Eggs that are not alike to the eggs of host birds are identified and are killed by host birds.
5. Escaped Eggs that are more alike to the eggs of host birds are come up with good health and chicks grow.
6. Estimate the habitat of each newly grown cuckoo
7. Reduce the cuckoos with maximum number in environment and kill those that live in worst habitats.
8. Cuckoos find best crowd and decide on goal habitat.
9. Let the new cuckoo population move toward goal habitat.
10. If the iteration is satisfied with stop condition then exit, else go to step 2.

Activation functions are the combination of mathematical as well as statistical equations that establish the output of a neural network. The function is appended to each neuron in the network, and concludes whether it should be activated or not, based on whether each neuron's input is relevant for the model's prediction. Activation functions also facilitate to standardize the output of each neuron to a range between 0 and 1 or between -1 and 1.An important characteristic of activation functions is that they must be computationally competent enough to calculate thousands and thousands of neurons given in the data samples.

In this paper, COA is applied to training neural networks in predicting Higher Education Institutions' academic performance. The merit of the COA algorithm and the success of ANN in the prediction of Higher Education Institutions academic performance have encouraged us to combine ANN and the COA algorithm. In this study, we propose an approach based on the multilayer feed-forward neural network improved by the COA algorithm for predicting academic performance of Higher Education Institutions, which makes use of the optimizing ability of this algorithm. To the best of our knowledge, this combination of the two artificial intelligence techniques is applied for the prediction of Higher Education Institutions academic performance in this research area. Cuckoo Optimization Algorithm (COA) is used for efficient activation of the neuron of Performance Prediction for Higher Education Institutions using Artificial Neural Network model.

Fig. 2 A Activation functions (COA) paradigm



The training will stop when Minimum Square Error [MSE] is obtained, which is the minimum error between targeted $y_i$ and predicted $y_p$ . MSE is given by:

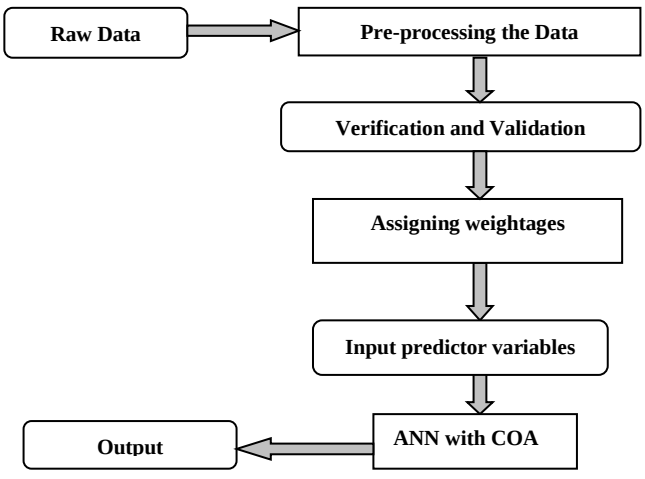
$$\mathbf{MSE} = \frac{1}{n}\sum_{1}^{n}(y_p - y_i)^2$$

## IV. Implementation Techniques and Analysis

A number of academic, social-economic, and other related factors that are considered to have an influence on the Higher Education Institution's academic performance were determined and chosen as independent input variables or predictor variables. The input predictor variables were obtained from the various data of the Higher Education Institution like (1) Curricular Aspects (2) Teaching learning and Evaluation (3) Research consultancy and Extension (4) Infrastructure of the Institution and learning Resources available (5) Student support and progression (6) Organization and management (7) Healthy Practices. The output variable can be changed to predict Higher Education Institution' performance based on the major seven academic criteria for the five academic years. The average score of theHigher Education Institution was chosen as the dependent output variable. In brief, there are seven input variables and one output variable in the proposed model. The data in the form of Input predictor variables and output variables is required to be pre-processed that to be appropriate for neural networks. The output variable has a range from 0 to 4 as Cumulative Grade Point Average (CGPA).

The model of the proposed method is illustrated in Figure 3. The massive quantity of raw data are preprocessed and then completed the verification and validation procedure with the help of the tools on hand, weightages are assigned to the criteria of the various Higher Education Institutions according to the assessment strategy given in Table 1.

Fig. 3 Performance Prediction paradigm incorporating ANN with COA



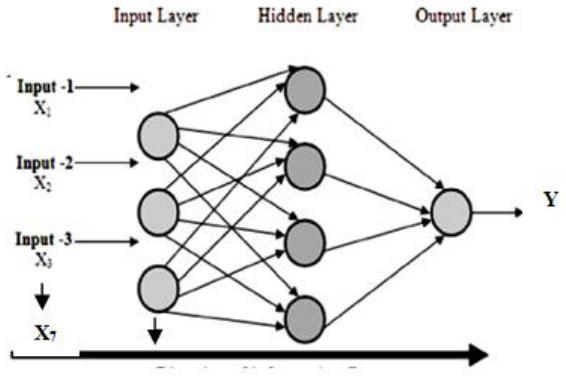

The criterion-wise differential input predictor variables and weightages for the three types of Higher Education Institutions are: U – Universities , Au – Autonomous Institutions, AFF UG – Affiliated to University (Undergraduate) and AFF PG – Affiliated to University (Postgraduate). Table 1 shows the Input Predictor Variables, it's Weightages and also its Output Parameter according to the heterogeneous type of Higher Education Institutions.

TABLE I
Input predictor variables, weightages and Output Parameter.

| S.No | Input Predictor Variables | Weightages | | | | Output Parameter |
|---|---|---|---|---|---|---|
| | | U | Au | Aff UG | Aff PG | |
| 1 | Curricular Aspects | 150 | 150 | 100 | 100 | CGPA Ranges from 0 to 4 |
| 2 | Teaching-learning & Evaluation | 200 | 300 | 350 | 350 | |
| 3 | Research, Innovations & Extension | 250 | 150 | 110 | 120 | |
| 4 | Infrastructure & Learning Resources | 100 | 100 | 100 | 100 | |
| 5 | Student Support & Progression | 100 | 100 | 140 | 130 | |
| 6 | Governance, Leadership & Management | 100 | 100 | 100 | 100 | |
| 7 | Institutional Values & Best Practices | 100 | 100 | 100 | 100 | |

Our neural network is a feed-forward network, with seven inputs, a single hidden layer, and a single output, illustrated in Figure 3.

Fig.4 ANN design for the proposed Method




Here is the procedure given to fix the number of hidden layers. Majority of problems need only one hidden layer, since it is better those NNs with more hidden layers are extremely hard to train. The following method can be used in setting the hidden layer configuration using the following rules:

(i) The number of hidden layers equal one;

(ii) The number of neurons in that hidden layer is calculated with the mean value of the neurons in the input layer and output layer.

(iii) The number of neurons in the hidden layer should be in between the size of the input layer and also the size of the output layer.

(iv)The number of hidden neurons should be 2/3 the size of the input layer, plus the size of the output layer.

(v) The number of hidden neurons should be less than twice the size of the input layer.

Number of neurons can be decided with the given formulae below:

$$N_h = \frac{N_S}{(\alpha * (N_i + N_o))}$$

Where $N_i$ = number of input neurons.
$N_o$ = number of output neurons.
$N_s$ = number of sample data sets available in the training data set.
$\alpha$ = an arbitrary scaling factor nonzero weights for each neuron [recommended *alpha* value between 5 and 10].

The sample training dataset and testing dataset were used to test the performance of the neural network. A general thumb rule to follow is to use 80: 20 training dataset and testing dataset as spilt.It is observed that a large amount of predicted values are close to the actual values. This trend indicates a good agreement between the predictions and the actual values. The comparison of performance criteria values of the neural networks trained by ANN with COA at different iterations are summarized as follows. After executing 200 and above iterations, the prediction model gives the Minimum Square Error [MSE] accuracy between the Training dataset and Testing dataset is approximately 0.02. After executing 500 and above iterations, the prediction model gives the Minimum Square Error [MSE] accuracy between the Training dataset and Testing dataset is approximately 0.04. After executing 1000 and above iterations, the prediction model gives the Minimum Square Error [MSE] accuracy between the Training dataset and Testing dataset is approximately 0.05. The results are to be the evidence that the ANN-COA has a better performance based on all criteria of the Higher Education Institutions. And also the prediction outcome of the ANN-COA model is more accurate and reliable too. Hence, the ANN-COA may be acceptable in serving as a predictor of Higher Education Institutions academic performance.

## V. Conclusions

The accurate prediction of Higher Education Institutions academic performance is of importance for making admission decisions for higher studies as well as providing funding by agencies for better educational services. In this study, the feed-forward neural network was utilized to predict Higher Education Institutions academic performance. This study used the powerful heuristic algorithm COA, based on the lifestyle of cuckoo birds to train ANN for predicting Higher Education Institutions academic performance. The results of the ANN-COA were then compared against in terms of MSE achieved. The ANN-COA was established to have considerably amount of accuracy in terms of predicting Higher Education Institutions academic performance. The findings demonstrated the remarkable advantage of the COA in training ANN and the potential of the ANN in the prediction of Higher Education Institutions performance. Our model is a user-friendly software tool for the prediction of Higher Education Institutions academic performance in order to make this task easier for educators.

## References


[1] P. M. Arsad, N. Buniyamin and J. A. Manan, "A neural network students' performance prediction model (NNSPPM)," 2013 IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA) , pp. 1-5, Kuala Lumpur, 2013.

[2] Ebrahimpour-Komleh,S.J. Mousavirad,"Cuckoo Optimization Algorithm for Feed ForwardNeural Network Training",21th Iranian Conference on Electrical Engineering, Ferdowsi University of Mashhad May, 14-16, 2013.

[3] Jabeen Sultana, M. Usha Rani, M.A.H. Farquad, "Student's Performance Prediction using Deep Learning and Data Mining Methods ",International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8, Issue-1S4, June 2019.

[4] Jinzhuo Zhang,xi Zhang , "Mapping the study of learning analytics in higher education", Behavior and Information Technology 37(10-11):1142-1155, November 2018.

[5] Lykourentzou, I.; Giannoukos, G.; Mpardis, V.; Nikolopoulos; Loumos, V. "Early and Dynamic Student Achievement Prediction in E-Learning Courses Using Neural Networks ", *.J. Am. Soc. Inform. Sci. Technol, 60*, 372–380, . 2009.

[6] Kawam, A.A.L.; Mansour, N. "Meta- heuristic Optimization Algorithms for Training Artificial Neural Networks".,*Int. J. Comput. Inform. Technol., 1*, 156–161, 2012.

[7] Kanakana, G., & Olanrewaju, A. "Predicting student performance in engineering education using an artificial neural network " Tshwane University of Technology, Proceedings of the ISEM, Stellenbosch, South Africa, 2011.

[8] Kahramanli, H. A "Modified Cuckoo Optimization Algorithm for Engineering Optimization.", *Int. J. Future Comput. Commun., 1*, 199–201, 2012.

[9] D. Magdalene Delighta Angeline, P. Rama subramanian and I. S. P. James, "Predicting Academic Performance in Teaching Learning Scheme Using Data Mining Practice," IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Coimbatore, 2017, pp. 1-5, 2017.

[10] M. Matetic, "Mining Learning Management System Data Using Interpretable Neural Networks," *2019 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, Opatija, Croatia, 2019, pp. 1282-1287.

[11] R. Rajabioun, "Cuckoo optimization algorithm," *Applied Soft Computing*, vol. 11, pp. 5508-5518, 2011.

[12] Timothy Wang and Antonija Mitrovic, "Using Neural Networks to Predict Student's Performance", Conference Paper , Department of Computer Science, University of Canterbury Private Bag 4800, Christchurch, New Zealand ,January 2002.

[13] K. Socha and C. Blum, "An ant colony optimization algorithm for continuous optimization: application to feed-forward neural network training," *Neural Computing & Applications*, vol. 16, pp. 235-247, 2007.

[14] Vandamme, J.P.; Meskens, N.; Superby, J.F. "Predicting academic performance by data mining methods" *Educ. Econ., 15*, 405–419, 2007.

[15] Vinod Kumar Pal, Vimal Kamlesh Kumar Bhatt. "Performance Prediction for Post Graduate Students using Artificial Neural Network", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-7S2, May 2019.