Maintainability Prediction for Software based on Class Diagram using Back Propagation Neural Network and Coco Search Algorithm

Anfal A. Fadhil
Assistance Lecture
Dept. of Software Engineering
University of Mosul, Iraq

ABSTRACT

accuracy and Software quality impacts user satisfaction and development costs ,Maintainability has gained its importance as a feature of software quality and the need for early indicators of external quality attributes is a a critical necessity ,maintainability of object-oriented software can be Predicted through the implementation of advanced modeling techniques . This paper presents model to a predicting the understanding and the modifiability as standard the maintainability software from class diagram using the Back propagation neural network with the Coco search algorithm .The results of this model are compared to multiple linear regression model, The results reported that the integration between Back propagation neural network with the Coco search algorithm is an improved maintainability expected with higher accuracy

Keywords

Maintainability, Back propagation neural network, Prediction , understanding, modifiability, Cuckoo search algorithm

1. INTRODUCTION

At present, many software engineers are an important factor: software quality , The maintainability process in early stages of the system is difficult because it contains a set of measures that must be accurately calculated, maintainability can be calculated at early stages of the system, for example at the design stage (design for object -oriented) for greater reliability, always quality Prediction Indicates Predicting maintainability or reliability of program, When designing a software product, it should be subject to a set of measure and the quality scale is considered to be the highest[1], maintainability is considered one of the most important quality metrics and a key criterion used by the institutions and evaluation centers of the software products in evaluating the economic success because maintainability reduce the time and effort in the maintenance phase, The software engineer must be familiar with the design components and how they work together to ensure high reliability,

the Studies of Statistics from different institutions show that between 40% and 80% of the Regular software development expenditure is You go in the maintenance phase where the software is updated ,the errors are Repair, Development the performance to meet changing field requirements[2], When the completion of the construction of any software product delivered to customers and start the product work, and may be some errors during the operation here begins maintenance phase to keep the system functioning properly and maintenance is a set of activities carried out by the maintenance team,

Many research works were conducted to Predict the extent of maintainability. To compute it, The Engineer needs to identify the required modifications by identifying the factors affecting the system to suit the desired change.It is also known that software maintenance time ,and Maintenance takes longer than development time [3].This paper performance of the proposed Cuckoo Search Back-propagation (CSBP) to predict software maintainability of object oriented system (class diagram) , Been relied on attributes understandability and attributes modifiability in class diagram to predict their maintainability Because they (understandability and modifiability) are considered the most important qualities of maintainability, and then comparisons of results with the technique of multiple linear regression

2. RELATED WORK

Several researches of the most up-to-date empirical studies about to Maintainability metrics:

Rizvi et al(2010).[4], developed a multivariate linear model in design(Object-Oriented software) phase for estimate the maintainability of UML class diagram in terms of understandability and modifiability.

Dubey .S et al(2012)[5] they used artificial neural networks(Multilayer Perceptron MLP) to predict maintainability of program and compare their results with other models and achieved the advantage

Momeni .H and Zahedian .SH (2014)[3] They suggested predicting the maintainability of aspect-oriented software by model ANFIS and Their results compared to the fuzzy logic model were the best

Kumar .L and Rath .S(2015)[6] they estimate software maintainability using hybrid of neural network and genetic algorithm. And compare Their results With the results of neural networks and gradient descent ,Their results was best .

Asadi .M and Rashidi .H(2016)[7] They suggested a new model to pridicate the maintainability depond on the measurements of new metric use summation for metrics and criticisms of the regression analysis, And applied their model on famous PHP framework and Their model was the best

3. MAINTENANCE

Maintenance is the precautionary measure to maintain or restore the an entity to normal or validating it to protect from failures ,The need for maintenance is necessary to modify a product after delivery to correct existing defects , improvement of the system performance and conditioning of the software to the newer environment ,Most researchers Classified maintenance as adaptive, corrective and preventive [8].

a Adaptive Maintenance: should be used This environment-based maintenance if there are modifications to devices, operating systems, files or compilers that have an impact on the system.

b. Corrective Maintenance: his error-driven activity is Resembles to the debugging process and occurs after the system is started. During a complete life cycle of corrective maintenance of the system is required because programs are prone to error in nature

c. Preventative Maintenance : It is used to Become the software more maintainable by update the documents, Changes made to the program product modification after delivery to detect and correct underlying errors [8] .

4. MAINTAINABILITY

According to IEEE standard Special of software engineering, maintainability is "The ease with which a software system or component can be modified to correct faults, improve performance or adapt to a changed environment" [9], maintainability is largely affected by the object-oriented approach of a system and the system is easily maintainable if at the design phase [10] , an object oriented system is decomposed into components and each component is further decomposed into sub-systems, Thus, a system is Considered to be maintainable if the change Impact less number of sub systems ,there are a set of scales for measuring the structural complexity of class diagram and to use this scales for predicting their maintainability , However, wide range adaptation of class diagram metrics in many application domains should only Occurs if the metrics are valid, meaning that it accurately measures the features of the software that are designed for measurement and has been verified experimentally [11],a set of metrics show in Table 1 [12] has been selected for Appreciation understandability and modifiability of class diagram metrics

Understandability : of the software system defines as the attributes of the program that uses the user efforts to identify different logical concepts. understandability of the software system Indicates the user requirements, state of their Acts

Modifiability: When the system needs to increase its performance to meet the requirements of the system developer then need to change the system tasks and this happens by changing the characteristics of the system to fit the performance increase, These changes are called modifiability[13]

Table 1: Measures of structural complexity for UML class diagram

name of Metric	Definition of Metric
sumC	Sum of The classes
sumA	Sum of The attributes
sumM	Sum of The methods
AssocN	The associations number
sumAgg	The sum of aggregation relationships within a class diagram

sumDep	Sum of The dependency relationships
sumGen	Sum of The generalization relationships (each super-sub pair in a generalization relationship)
sumAGGH	Sum of The aggregation hierarchies.
sumGenH	Sum of generalization hierarchies in a class diagram
MaxDit	It is the maximum of the DIT value for each class of the class diagram.
Max HAggr	It is the maximum the HAggr value for each class The HAggr value for a class is the large path from the class to the leaves

5. PROPOSED WORK TO FORECAST MAINTAINABILITY

This section Shows the Merge between techniques of artificial intelligence (AI) for predicting maintainability ,Where the merge between cuckoo search algorithm and Back propagation Neural Network

5.1 Back propagation Neural Network(BPNN)

The BPNN is One of the most famous networks under supervision for its ease, and its ability to store information implicitly in links ,The weights that connect one cell to another and learn BPNN are calculated by compute output layer errors to find errors in hidden layers ,The back propagation neural network Contains of at least three strata of cells: the input strata, the hidden strata, and the output strata [6] and figure (1) explain the Back propagation architectural , with a reverse spread and although this network has been successful in many But it is not the panacea for all issues, for example complex issues need to be resolved Time is too big
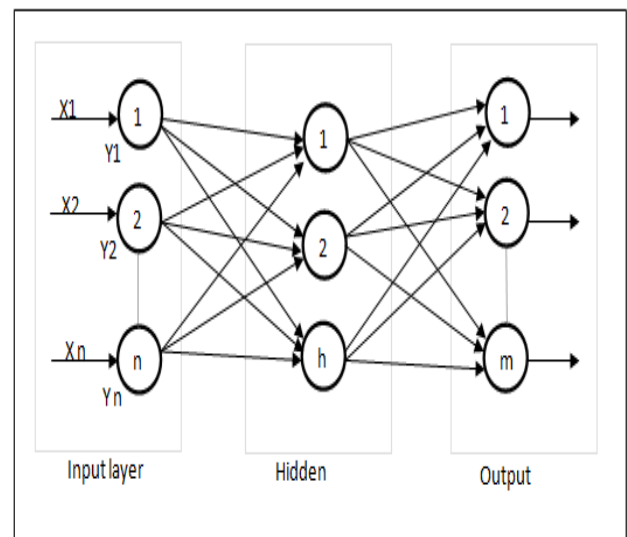

Fig 1: architectural of the Back propagation neural network

5.2 Cuckoo search algorithm CSA

This algorithm depends on the behavior of the bird in the encroachment and placing its eggs in the nests of other birds as brood parasitism, "CSA is enhanced by the Levy flights which give it more potential than evolutionary algorithms"[14], CSA job Accredited on the following three steps:

1. Each cuckoo bird at a time puts the an egg in the occupied nest

2. The nest with the better type of eggs will turns up for new generation, and the minimum type will be Neglected.

3. The total number of occupied nests is repaired. when Owner of the nest can reveal a cuckoo's egg , then Crash the nest and create other nest.

In a mathematical way, basic rule is a random procedure Featuring by Levy flights. While a next solution generate,

, $x^{(i+1)}$ for the j^{ih} cuckoo bird, the levy flight execute is by following the Equation(1)

$$x_j^{(i+1)} = x_j^i + \text{a levy(h)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where a is a positive value whose size change depending on the optimization sample, Levy Flights is a random gait

that is features by a set of right jumps , and i appear the present generation

5.3 The Proposed CSBP Algorithm

In this research an algorithm was applied an algorithm cuckoo search (CS) with Back propagation(BP) Neural Network, to find the best weights for the Metrics in table1 to compute understanding and modifiability that are considered to be the most important standards of Maintainability, and Figure 2 illustrates the proposed CSBP algorithm

the BP Neural network considered successful in many applications but is subject to a problem Network paralysis The result of the wrong selection of weights, especially if weights were chosen large numbers, it means The change in these weights will produce very large numbers, leading to the fact that all or most of the cells in the network produce significant values for real output While the activation function is derived with small values This leads to grid paralysis, so you should choose small initial numbers for weights and reduce the learning rate But training time will increase. And by doing a number of tests It turns out that if the learning ratio is too small, this leads to approaching the solution The correct will be very slow, but if the learning ratio is too large, this leads to paralysis of the network. And to solve all these problems in the BP network and accelerate its work has been It was used with an Cuckoo Search algorithm,
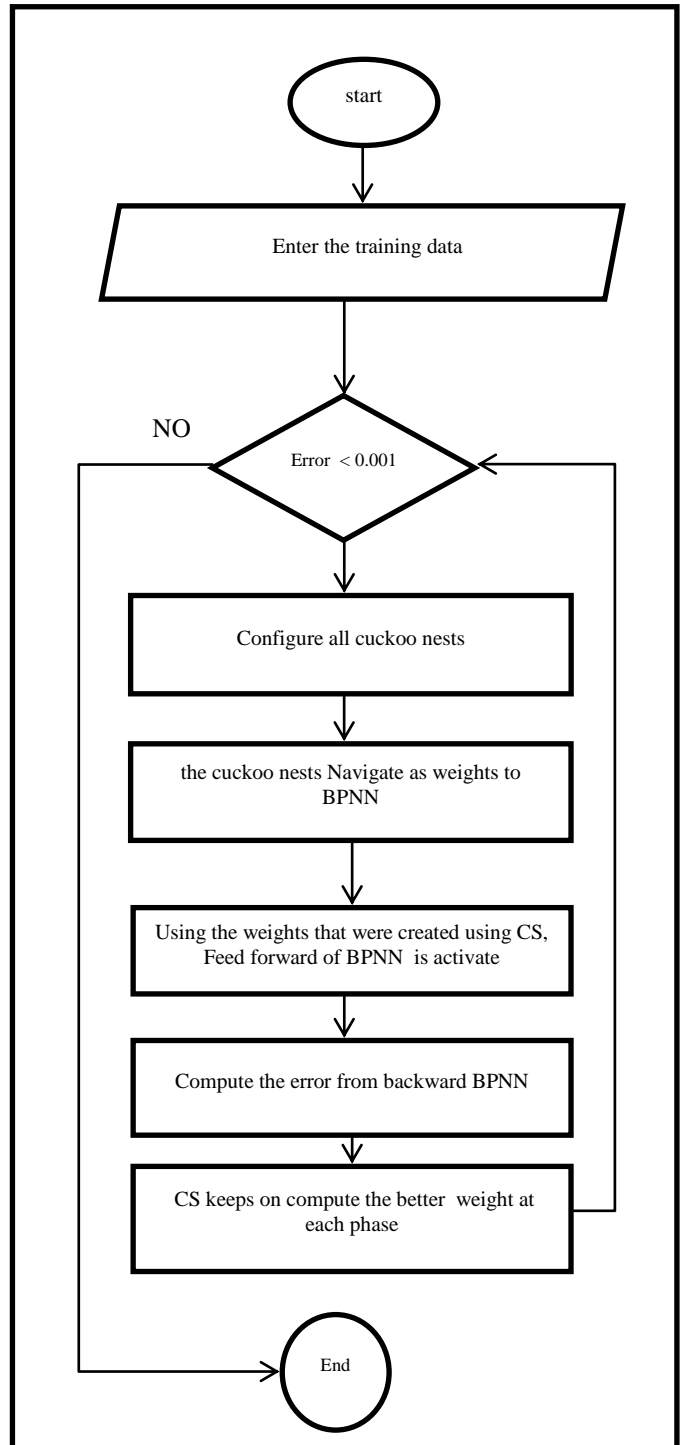

Fig 2: the flowchart of the CSBP algorithm

In the proposed Cuckoo Search Back propagation algorithm (CSBP) each better nest representations a possible solution .The quality of the solution see in the volume of population and issue of weight improvement , In the first phase, Using an CS algorithm the weights are initialized and these weights are considered to be introduced to BPNN where they are updated and the weights are calculated optimally. The weights in BPNN are compute according to the equation (2,3) and find rapprochement with best solution in the backward direction, Where it was used sigmoid as activation function of efficiency used in the network Back propagation ,that is described as a simple derivative, used in the implementation of the algorithm.

$$\text{Output} = f(NETj) = \frac{1}{1+e^{-NETj}} \qquad (2)$$

$$f(NETj) = output(1 - output) \qquad (3)$$

In the next stage, CS is done Depending on the best result and continue work to find the weights until The error rate is less than 0.001,

6. COMPARISON OF RESULTS

Data set used during the study has Depends on search Genero et al. [12]. It consist of   eleven metrics (show in Table 1) to Predicts understandability, modifiability for maintainability ,after applying The proposed CSBP algorithm on this data from 28 class diagrams the Optimal weights were obtained for the metrics shown in Table1 to Predicts   understandability, modifiability, the figure(3) show The results obtained from applying the CSBP algorithm proposed to Predicts understandability with the actual results ,and figure(4) show The results obtained from applying the CSBP algorithm proposed to Predicts understandability with the actual results and the results achieved by Rizvi .S et al [4] Using multiple linear regression, the figure(5) show The results obtained from applying the CSBP algorithm proposed to Predicts Modifiability with the actual results ,and figure(6) show The results obtained from applying the CSBP algorithm proposed to Predicts Modifiability with the actual results and the results achieved by Rizvi .S et al [4] Using multiple linear regression ,and from the result Note that the algorithm CSBP achieved higher quality than linear regression quality . and the table (2) show Correlation values between the values calculated using the CSBP algorithm   for the (Understandability ,Modifiability , Maintainability) and the actual values are strongly correlated
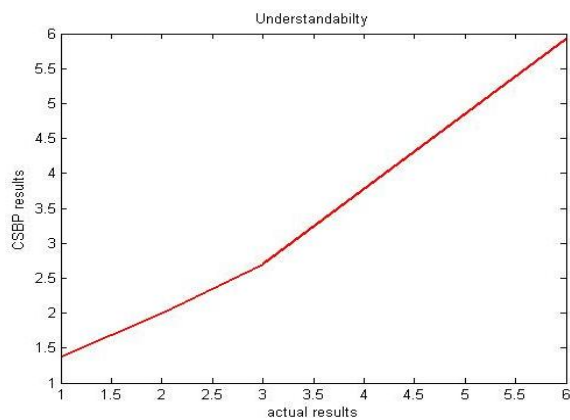

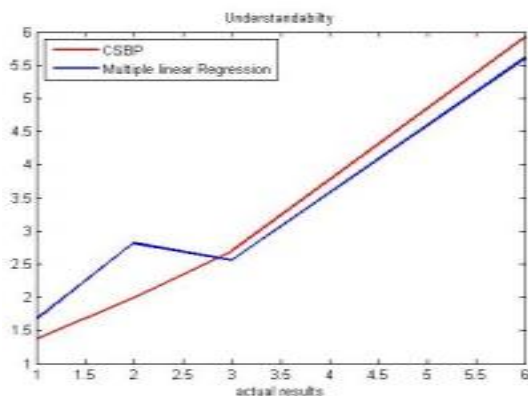**Fig 3: CSBP and actual results to Predicts understandability**

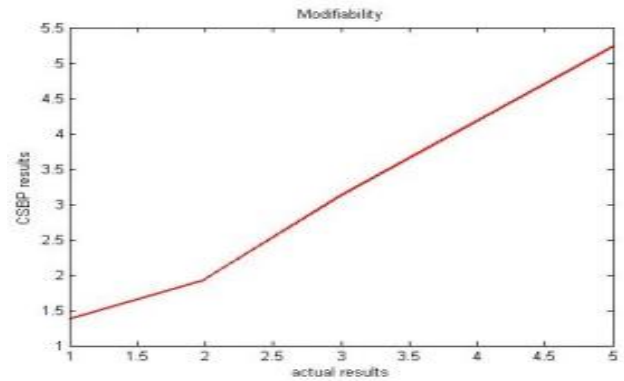**Fig 4:CSBP and multiple linear regression and actual results to Predicts understandability**

Fig 5: CSBP and actual results to Predicts Modifiability
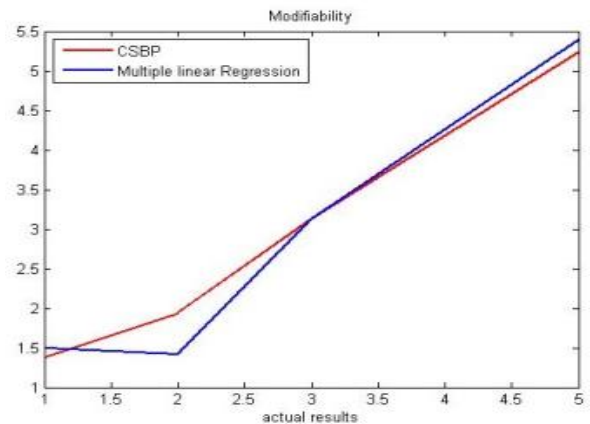

Fig 6: CSBP and multiple linear regression and actual results Predicts Modifiability

Table 2: Pearson's Correlation between CSBP and Actual result

	Correlation between CSBP Algorithm Result and Actual Result
Understandability	0.968
Modifiability	0.989
Maintainability	0.982

7. CONCLUSIONS AND FUTURE WORK

In this paper a new algorithm was introduced based on the integration of the Cuckoo Search algorithm with Back propagation Neural Network algorithm to obtain optimal weights for the metrics used to predict external quality characteristics such as maintainability in the initial stages of the life cycle of the system is class diagram ,and the error ratio for BPCS algorithm was 0.001,The results were compared with the results of research by Rizvi .S et al Using multiple linear regression, and it was found that the proposed algorithm achieved better results to predict the characteristics of maintainability such as: understanding and modifiability ,to ensure a significant correlation between these metrics values and maintainability, was analyzed the results using the Pearson's correlation.It was found that the weights values for each metrics are closely related to the characteristics of maintainability such as: understanding and modifiability.

In future work Can be applied are sub-characteristics of maintainability such as flexibility and extendibility On artificial bee colony algorithm or other algorithms

8. REFERENCES

[1] Dhaka V, AgrawalS, Optimization of Object-Oriented Metrics Using Hopfield Neural Network, International Journal of Soft Computing and Engineering (2231-2307) Volume-3, Issue-3, July 2013

[2] DubeyS,Rana A, A Fuzzy Approach for Evaluation of Maintainability of Object Oriented Software System, International Journal of Computer Applications (0975 – 8887) Volume 49– No.21, July 2012

[3] Momeni H, Zahedian SH, Aspect-Oriented Software Maintainability Assessment Using Adaptive Neuro Fuzzy Inference System (ANFIS), Journal of mathematics and computer Science 12 (2014) 243 - 252

[4] RizviS,Khan R, Maintainability Estimation Model for Object-Oriented Software in Design Phase(MEMOOD), JOURNAL OF COMPUTING, VOLUME 2, ISSUE 4, APRIL 2010, ISSN 2151-9617

[5] DubeyS ,Rana A, Dash Y, Maintainability Prediction of Object-Oriented Software System by Multilayer Perceptron Model, ACM SIGSOFT Software Engineering Notes, September 2012 Volume 37 Number 5

[6] Kumar L,Rath S, Neuro – Genetic Approach for Predicting Maintainability Using Chidamber and Kemerer

[7] Software Metrics Suite, Recent Advances in Information and Communication Technology 2015

[8] Asadi M, Rashidi H, A Model for Object-Oriented Software Maintainability Measurement, I.J. Intelligent Systems and Applications, 2016, 1, 60-66

[9] Dash Y,Dubey S, Maintainability Measurement in Object Oriented Paradigm, International Journal of Advanced Research in Computer Science, 3 (2), March –April, 2012, 207-213

[10] P. Hasia, A. Gupta, C. Kung, and J. Peng, "Study on the effect of architecture on maintainability of object- oriented systems", IEEE Conference on Software Maintenance, pp. 4-11, 1995

[11] N. Tagoug, "Maintainability assessment in Object Oriented System design", International Conference on Information Technology and e-Services (ICITeS), pp 1-5, 2012[

[12] N.F. Schneidewind, "Methodology for Validating Software Metrics, "IEEE Trans. on Software Engineering, vol. 18, no. 5, pp. 410 - 422, 1992

[13] Genero M, OlivasJ, Piattini M, Romero F, A controlled experiment for corroborating the usefulness of class diagram metrics at the early phases of OO developments, , Workshop on Decision Support in Software Engineering, vol. 84.Spain, 2001.

[14] Singh H, Kumar A, A NOVEL APPROACH TO ENHANCE THE MAINTAINABILITY OF OBJECT ORIENTED SOFTWARE ENGINEERING DURING COMPONENT BASED SOFTWARE ENGINEERING , International Journal of Computer Science and Mobile Computing, Vol.3 Issue.3, March- 2014, pg. 778-786

[15] Xin-She, Y.: 'Cuckoo Search and Firefly Algorithm Theory and Applications', Studies in computer intelligence,2013, 516