Cuckoo Search based Hybrid Classification Techniques

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Abstract

Data classification is one of the major tasks in data mining that organizes data in the proper manner to provide enhanced functionality to extract useful information from that data. There are various supervised and unsupervised machine learning techniques like FNN (Fuzzy Neural Network) presented by the researchers to provide an enhanced classification of the dataset. But the performance of the classification highly depends on the selection of the parameters, which is used to classify the dataset. Enhanced subset of parameters can provide enhanced classifiers to classify data. There are various optimization techniques like ACO (Ant Colony Optimization) and some others which are used to provide optimized parameters to classify data. But Cuckoo search is an optimization technique which provides a simple and easy functionality to optimize parameter rather than the other techniques. A review over the various hybrid classification techniques which are used to classify and also uses Cuckoo Search based parameter optimization technique, is presented in this paper. It shows that Cuckoo Search provides enhanced and easy tune with other techniques to enhance performance of the classification. A BDT-SVM and Cuckoo Search based technique is presented for the future to provide enhanced classification for the data.

Keywords

Classification, Cuckoo Search, Machine Learning, Fuzzy neural Network.

I. Introduction

Classification is the process of categorizing the data. In nature, data is present in heterogeneous form thus proper categorization of the data is required to provide better performance for extracting useful information from the data. In machine learning, data classification is the problem of categorizing dataset into various classes or subsets used to perform various data extraction tasks, for that a training dataset or a predefined classified dataset is used to provide better classification for the new observations. Algorithms which are used to classify the data are known as classifiers. The performance of the classifiers depends on the selection of the parameters. Optimized parameters are required to generate better classifiers for the data.

There are various parameter optimization techniques like particle swarm optimization, Ant colony optimization, and Bee colony optimization etc. are present in nature which used to provide optimized parameter to classify the data and generate optimized classifiers. But these techniques do not have easy adaptability to the other technique which degrades the performance of the whole system.

A. Cuckoo Search

Cuckoo search is a parameter optimization technique which came into existence in 2009. The obligate brood parasitism of some cuckoo species inspires this technique. These birds lay their eggs in other bird's nest. Some host birds can recognizes that egg; in that case these birds either throw that egg or simply leave their nest and construct a new one.

Cuckoo Search is mainly based on three rules:
1. Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest;
2. The best nests containing high quality of eggs will carry over to the next generation.
3. The number of available host's nests is constant, and the host bird discovers the egg laid by a cuckoo with a probability $p_a \in (0,1)$. Discovering operates on some set of worst nests, and discovered solutions dumped from farther calculations.

Levy Flight: Levy flight is a random walk in which step-length is distributed according to the heavy tailed probabilities. That random walk can be linked similarity between cuckoo's egg and host's egg. Here the step size S determines how far a random walker can go for a specified number of iterations. The generation of Levy step size is often tricky, and a comparison of three algorithms (including Mantegna's) was performed by Leccardi who found an implementation of Chambers et al.'s approach to be the most computationally efficient due to the low number of random numbers required.

The new solution generated will be too far away from the old solution (or may jump out side of the bounds) if s is too large. Such a move is unlikely to be accepted. And if s is too small, the change is too small to be significant, and therefore such search is not efficient. Thus a proper step size is important to maintain the search as efficient as possible.

Rest of the paper organizes as follows: Section II gives a brief review over the techniques which were used to provide better classification for the data and section III concludes the paper.

II. Literature Review

A brief literature review over the various techniques which used for the data classification and optimization is presented in this section.

Classification is the process of categorizing data into different classes, to classify data into two classes is an easy task but classify data into multiple classes is not an easy task to do. Thus there are various techniques presented by the researchers to provide better performance to classify data. But a single technique is not able to provide better performance. A hybrid technique called Cuckoo Search based Functional Link Neural Fuzzy Networks (CSFLNFN) [1] is presented to classify data into multiple classes. In FLNFN, neural network based efficient computational technique and a fuzzy logic based technique is used to take advantages of both the techniques and converges limitation of both techniques. Functional Link Neural Network is a technique in which single layer and single neuron can be used to perform classification tasks. Input data can go through the set of basic functions and trigonometric function can be used to match the input vector with the high dimensional feature space. Fuzzy logics are used to map these input vectors.

A Cuckoo Search optimization technique which uses to optimize the parameter of various machines learning technique can be used to provide enhanced performance. Cuckoo search works

on the behaviour of birds of the Cuckoo species. These birds lay their eggs into the nest of the other bird's nest. If that egg is recognized by other bird, it either throws that alien egg or destroys that nest and makes a new one. This property is used to optimize the parameters of the various machines learning technique. It provides easy and simple mechanism for optimization.A hybrid technique which provides enhanced functionality to classify data is presented. This technique provides efficient computation of neural networks and fuzzy logics, and parameter optimization of Cuckoo search technique. This technique provides enhanced classifiers to classify data. But in this technique, a neural network based technique is used which is having complex functionality to classify data. A simple machine learning technique like KNN (K-Nearest Neighbour), SVM (Support Vector Machine) etc. technique can be used to provide enhanced classified to classify data.

Web service composition [2] is the problem which focuses on selecting an optimal configuration of the web services to provide web services to the user that satisfies functional and non-functional requirement of the user. The data over web increases continuously and there various services which provide same type of functionality; to select optimal composition of the web services is a difficult task to do. A Single technique was not able to provide optimal solution to the user for such problems. Thus a hybrid technique which takes Cuckoo search and evolutionary algorithm based techniques are used to provide better solution for the user it also uses tabu search, and reinforcement learning to provide enhanced functionality to select web services for user. In Cuckoo search artificial cuckoo are used which behaves in same manner as original cuckoo does. Containers id and solution associated to that container is used to optimize the solution for the problem, previous solution is replaced by the new one to optimize the solution. Reinforcement learning, evolutionary algorithm, and tabu search techniques are used to provide efficiency over time in cuckoo search algorithm.

Stock market [3] is one of the important sources of raising resources in the India; there are factors like economic conditions, investor's sentiments and political events etc. which are affecting stock market performance. Predicting and forecasting is one of the major tasks in stock market. There are three types of predictions called short term, long term and medium term which are performed. In short term forecasting, prediction may be for 10 minutes, for hours or for a week. In medium term forecasting, forecasting about the period of above a week or within a month is performed. In long term forecasting period of a year or few years is taken. To perform prediction task ANN (Artificial Neural Network) based techniques are generally used. But these techniques degrade in efficiency over time and also use a complex functionality to perform all the tasks. SVM (Support Vector Machine) a machine learning technique is widely used technique to perform that task. To enhance the performance of SVM, Cuckoo Search, a parameter optimization technique is used to provide better performance for the user. Cuckoo Search is parameter optimization techniques which can be easily tune with the SVM and prove an enhanced performance to forecast about the stock market. A CS-SVM (Cuckoo Search-Support Vector Machine) is presented. That provides an enhanced functionality to forecasting about the stock market by optimizing the SVM classifiers. But in this technique, only factors like economic conditions, investor's sentiments, political events are taken to forecasting about the stock market. There are some other factors like gold price, crude oil price, fluctuation in dollar price are also consider to provide better forecasting. And an enhanced variant of SVM can also be used to provide enhanced functionality for forecasting.

Proteins[4] are the main constituents or building blocks for the living organs and DNA replication. And also performs wide range of biological functions. Protein structure prediction is one of the major tasks in bioinformatics. Knowing about the structure of the protein helps in drugs design and disease prediction. Thus there are various techniques suggested by the researchers to provide solution to predict structure of the proteins.A cuckoo search based technique with the AB off-lattice model is presented. AB lattice model is one of the widely used models for the protein structure prediction. This model predict about the secondary structure of the proteins from the sequence of its amino acids. It is a model based on thermodynamics concept which state that secondary structure of the protein based on the minimum free energy. Thus the main task is to find a native structure of the protein with the minimum free energy state. A Cuckoo search technique is used to provide enhanced performance by optimizing the parameters of the model.

Fuzzy neural network (FNN) in one of the widely used model for the applications like pattern recognition, data classification, image processing etc. this technique is used to solve the problems, where there is no mathematical model to solve the problem. FNN is having universal approximation property to provide solution for the various problems. That property provides flexibility to design learning machine for the various problems. In FNN incremental gradient descent approach with Back Propagation technique is used. But solutions provided by this technique get trapped to the local minima, especially for the non-linear classification problems. It is also sensitive for the initialization of collection weight and learning rate that also degrades the performance of the whole technique. Cuckoo Search algorithm for the parameter optimization and simplex method which provide solution for the local minima optimization is used. It overcomes the limitations of the fuzzy neural networks. This technique provides enhanced functionality to enhance the performance of classification of the non-linear data and provide solution for local minima problem. [5]

Fingerprint detection[6] is a generally used technique for the biometric password. Thus a high quality image is required to provide better performance to detect fingerprint. As fingerprints of one person are always different from the others, thus a low quality image can degrade the performance of the whole technique. There are various technique presented by the researchers to provide an enhanced image to detect fingerprint. A high contrast image provides better functionality as compare to the low contrast image. A Cuckoo search based technique is proposed by the author to provide high contrast image for fingerprint detection. That technique enhances both qualitative and quantitative enhancement in the image and reduces the noise and eradication in the image. Cuckoo Search is a parameter optimization technique which provides easy and simple functionality to optimize parameters. In existing technique, filtering and pixel intensity based techniques are used to enhance the contrast of the image, but these techniques are very time consuming. Cuckoo Search provides enhanced functionality to detect fingerprint.

Performance of the classifiers in classification depends on the selection of the parameters, which is used to classify dataset. It is not possible every-time to select optimal parameters for the classification, which generates the problem of over-fitting and inaccuracy in the classification.Thus a Cuckoo search based technique[7] is presented to provide an optimal subset of parameters to classification. This technique enhances the whole classification accuracy and provides accurate classifiers to classify data. That

minimizes the classification error and reduces dimensionality of the attribute vectors.A k-nearest neighbour based classification technique with cuckoo search technique is presented to provide advanced classification to the datasets.

A novel Cuckoo search algorithm [8] is presented in this paper which uses Gamma Distribution instead of Levy distribution. Because levy distribution is a normal and simple distribution and it takes location and scale parameter and two shape parameter. It does not give the desired performance that is required. So a gamma distribution is used to which only takes Shape parameter Alpha and an inverse scale parameter as rate factor. That enhances the functionality of the conventional Cuckoo search algorithm. And provide accurate and optimal results as compare to conventional algorithm.

A Hyper Cube framework for Ant Colony Optimization technique[9] is presented by the author in this paper. In ant colony optimization, it is based on the behaviour of the ants during the process of finding food. In this process first an ant search all around its reach in random manner and when it finds food, then during the returning process ant deposits a chemical called pheromone. The quantity of pheromone depends on the quantity and quality of the food. This pheromone helps other ants to find shortest path between their nest and food source. Same technique is used with artificial ants to find an optimized path for a given problem. But this method does not provide an efficient solution for large scale data. Thus a hypercube framework is presented in this paper which is used to change rules of pheromone update, in that the value of the pheromone is limited for the interval of {0,1} that enhances the performance of the ant colony optimization system.

For solving multiclass problems, a novel architecture of Support Vector Machine classifiers utilizing binary decision tree (SVM-BDT) is presented by the author [10]. The hierarchy of binary decision subtasks using SVMs is designed with a clustering algorithm. Clustering model utilizes distance measures at the kernel space, rather than at the input space for consistency between the clustering model and SVM. A clustering algorithm is used that utilizes distance measures at the kernel space, to convert the multi-class problem into binary decision tree, in which the binary decisions are made by the SVMs .Advantage of both the efficient computation of the decision tree architecture and the high classification accuracy of SVMs are taken by the proposed SVM based Binary Decision Tree architecture. The SVMBDT architecture provides superior multi-class classification performance, requires much less computation for deciding a class for an unknown sample. Performance of SVMBDT architecture was measured on samples from MNIST, Pendigit and Statlog databases of handwritten digits and letters. The results indicates that while offering better accuracy with other SVM based approaches, ensembles of trees and neural network, the training phase of SVM-BDT is faster. During recognition phase, SVM-BDT is much faster than the widely used multi-class SVM methods like OaO and OaA, for multiclass problems. The experiments also show that the proposed method becomes more favourable as the number of classes in the recognition problem increases.

For classification post-processing, the author [11] presents a method for extracting probabilities p(class|input) from SVM outputs. Standard SVM do not provide such probabilities. In this method first we train an SVM, then we train the parameters of an additional sigmoid function that is used to map the SVM output into probabilities. In the Experimental steps SVM+sigmoid yield probabilities are compared to the raw SVM, it preserves the sparseness of the SVM and also produces probabilities that are of comparable quality to the regularized likelihood kernel method. An effective way for solving multiclass problem is Binary tree support vector machine, which combines support vector machine and binary trees. Structure of the binary tree relates closely to classification accuracy and decision speed of the classifier Author [12] proposed that, to maintain high generalization abilities, the most separable classes should be separated at upper nodes of the binary tree to maintain the high generalization ability.. A new binary tree with fewest levels is established based on clustering method. By comparing with oblique binary tree, balance binary tree and unbalance binary tree, the experiment result shows lower decision time and better accuracy with 93.59% .

Decision tree based support vector machine combines support vector machine and decision tree for solving multi-class problems in Intrusion Detection Systems in an effective way. This method increases efficiency and decreases the training and testing time of the system. In binary tree, the construction order has great influence on the classification performance. In this paper [12] two decision tree approaches are used: Hierarchical multiclass SVM and Tree structured multiclass SVM. They divide the data set into two subsets from root to the leaf until every subset consist only one class,thus includes different ways to construct the binary trees . For measuring the separability between the classes euclidean distance is used.

Decision tree SVMs architecture was proposed by the author which is constructed to solve multi-class problem. By determining optimal structure of decision tree using statistical measures for obtaining class separability ,this paper [14] maintain high generalization abilities. Advantage of both the higher classification accuracy of SVM and efficient computation of decision tree architecture are taken by Optimal decision tree (ODT-SVM). A non-parametric test is carried out over multiple data sets for statistical comparison of proposed ODT-SVM with other classifiers. Performance is evaluated in terms of computation time and classification accuracy. The UCI repository datasets are analyzed and it indicates that ten cross validation accuracy of our proposed framework is significantly better than widely used multi-class classifiers. Highest achieved accuracy is 100%. Experimental performance shows that in terms of both training and testing time ODT-SVM is significantly better in comparison to OaO and OaA.

An improved version of One-against-All(OAA) method is presented by the author[15] for multiclass SVM classification based on decision tree. The decision tree based OAA (DTOAA) uses posterior probability estimates of binary SVM outputs to aim at increasing the classification speed of OAA. When compared to OAA and other multiclass SVM methods, the average number of binary SVM tests required in testing phase is decreased to a greater extent in DTOAA. DTOAA requires only $(K + 1)/2$ binary tests on an average as compared to K binary tests in OAA in a balanced multiclass dataset with K classes; however, on imbalanced multiclass datasets, DTOAA is observed to be much faster with proper selection of order in which the binary SVMs are arranged in the decision tree. By compairing the result indicates that the proposed method can achieve almost the same accuracy as OAA with 99.92% but is much faster in decision making.

The existing binary classifier techniques run into serious efficiency problems for mapping multiclass problems onto a set of simpler binary classification problems, when there are hundreds or even thousands of classes, and here the author [16] provides solution to this problem. Author introduces the concept of correlation and joint probability of base binary learners. During the training stage we learn these properties, and group the binary learner's based on

their independence, combine the results using a Bayesian approach to predict the class of a new instance. Lastly, we discuss two additional strategies: one is to reduce the number of base learners required in the multiclass classification, and second is to find new base learners, that might be best for the existing set. These two new procedures are used iteratively to complement the initial solution and improve overall performance. The highest accuracy achieved is 96%. The two goals are: to find the most discriminative binary classifiers to solve a multiclass problem and keep up the efficiency, i.e., small number of base learners.

In this paper the authors [17] propose and examine the performance of a framework, for solving multiclass problems with Support Vector Machine (SVM). The proposed model builds a binary tree for multiclass SVM, using the technique of partitioning by criteria of natural classification i.e. Separation and Homogeneity, aiming to obtain optimal tree. However, the main result is the mapping of the multiclass problem into a several bi-classes sub problems, in order to ease the resolution of the real and complex problems. In the construction of the tree our approach is more accurate. Further, in the test phase OVA Tree Multiclass is much faster than other methods in problems that have big class number, due to its Log complexity. In this context, to evaluate our framework two corpus are used; one is TIMIT datasets for classification of vowel and MNIST for handwritten digits recognition. A recognition rate achieved was 57% on the 20 vowels of TIMIT corpus and 97.73% on the 20 digits of MNIST datasets. Also the number of support vectors and training time, which mainly determines the duration of the tests, is reduced compared to other methods.

To solve multi-class problems, the tree architecture has been employed based on SVM. It is an alternative to the OVO/OVA strategies. Generally, the tree base SVM classifiers try to split the multi-class space into several binary partitions, by some clustering like algorithms. The main drawbacks of this are that the natural class structure is not taken into account and also the same SVM parameterization is used for all the classifiers. Here author [18] presents a preliminary and promising result of a multi-class space partitioning method that accounts for data base class structure and allows node's parameter specific solutions. The space is split into two class problem possibilities in each node and the best SVM solution is found. Preliminary results show that the accuracy is improved, information required is less, hard separable classes can easily be identified and each node reaches its specific cost values.

In this paper, author [19] presents a novel architecture of Support Vector Machine classifiers for solving multiclass problems utilizing binary decision tree (SVM-BDT). The hierarchy of binary decision subtasks is designed with a clustering algorithm using SVMs. The clustering model utilizes distance measures at the kernel space, instead of at the input space, for consistency between the clustering model and SVM. Advantage of both the high classification accuracy of SVMs and the efficient evaluation of the decision tree architecture are taken by the proposed SVM based Binary Decision Tree architecture. To provide superior multi-class classification performance the SVMBDT architecture was designed. Its performance was evaluated on samples from MNIST, Pendigit, Optdigit and Statlog databases of handwritten letters and digits. The results of the experiments indicates that the training phase of SVM-BDT is faster, while maintaining comparable or offering better accuracy with other SVM based approaches. During recognition phase, SVM-BDT is much faster than the widely used multi-class SVM methods like OAO (one-against-one) and OAA (one-against-all) due to its logarithmic complexity, for multiclass problems. The experiment also shows that the proposed method becomes more favourable as the increase in number of classes in the recognition problem.

The authors [20] describe an original classification technique, the Probabilistic Decision Tree (PDT) producing a posteriori probabilities in a multi-class context in this paper. This is based on a Binary Decision Tree (BDT) with Probabilistic Support Vector Machine classifier (PSVM). At each node of the tree, a bi-class SVM are trained along with a sigmoid function to give a probabilistic classification output. The outputs of all the nodes composing the branch are combined, to lead to a complete assessment of the probability when reaching to the final leaf. To demonstrate the effectiveness of PDTs, testing is done on benchmark datasets and results are compared with the other existing methods. The highest accuracy achieved is 92.75% when compared to other multiclass methods, such as OvO, DAG, RL-BDT.

III. Conclusion

Classification is one of the major tasks in data mining which is used to provide enhanced functionality and extract useful information from the data. Selection of the parameters puts huge impact over the performance of the classifiers. There are various optimization techniques which can be used to optimize the performance of the classifiers to classify data. A review over the technique which used Cuckoo search algorithm to optimize the performance of the classifiers is presented in section II Literature Review, which shows Cuckoo search is an enhanced and easy to tune with the other technique, to provide optimized classifiers to classify the data. For future work, a hybrid technique is used which uses BDT-SVM and Cuckoo Search to provide an enhanced mechanism to classify the data.

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