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Cuckoo Search: A Classification Technique a study

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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 selectionoftheparameters,whichisusedtoclassifythedataset. Enhanced subset of parameters can provide enhancedclassifiers to classify data. There are various optimization techniques like ACO(AntColonyOptimization)andsomeotherswhichareused 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 othertechniques.Areviewoverthevarioushybridclassification techniques which are usedtoclassifyandalsousesCuckooSearch based parameter optimization technique, ispresentedinthispaper.* ***ItshowsthatCuckooSearchprovidesenhancedandeasytunewith 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 thedata.***

Keywords: *Classification, Cuckoo Search, Machine Learning, Fuzzyneural Network.*

I. Introduction

Classification is the process of categorizing the data. In nature, data is present in heterogeneous form thus propercategorization ofthedataisrequiredtoprovidebetterperformanceforextracting useful information from the data. In machine learning, data classification is the problem of categorizing dataset into various classesorsubsetsusedtoperformvariousdataextractiontasks,forthatatrainingdatasetorapredefinedclassifieddatasetis usedto providebetterclassificationforthenewobservations.Algorithms which are used to classify the data are known as classifiers. The performance of the classifiers depends on the selection of the parameters.Optimizedparametersarerequiredtogeneratebetter classifiers for thedata.

Therearevariousparameteroptimizationtechniqueslikeparticle 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 wholesystem.

A. Cuckoo Search

Cuckoosearchisaparameteroptimizationtechniquewhichcame into existence in 2009. The obligate brood parasitism of some cuckoospeciesinspiresthistechnique.Thesebirdslaytheireggs 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 arandomly chosen nest;
2. Thebestnestscontaininghighqualityofeggswillcarryover to the next generation.
3. Thenumberofavailablehost'snestsisconstant,andthehost birddiscoverstheeggslaidbyacuckoowithaprobability . Discovering operates on some set of worst nests, and discovered solutions dumped from farther calculations.

LevyFlight: Levyflightisarandomwalkinwhichsteplengthisdistributedaccordingtotheheavytailedprobabilities.Tha trandom walk can be linked similarity between cuckoo's egg and host's egg. Here the step size determines howfararandomwalkercan 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. Suchamoveisunlikelytobeaccepted.Andifsistoosmall,the change is too small to be significant, andtherefore suchsearchis notefficient.Thusaproperstepsizeisimportanttomaintainthe search as efficient

aspossible.

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 whichused for the data classification and optimization is presented in this section.

Classification is the process of categorizing data into different classes,toclassifydataintotwoclassesisaneasytaskbutclassify 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 isnot able to provide better performance. A hybrid technique called Cuckoo Search based Functional Link Neural Fuzzy Networks (CSFLNFN)[1]ispresentedtoclassifydataintomultipleclasses. InFLNFN,neuralnetworkbasedefficientcomputationaltechnique and a fuzzy logic based technique is used to take advantages of boththetechniquesandconvergeslimitationofbothtechniques. 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 trigonometricfunctioncanbeusedtomatchtheinputvectorwith thehighdimensionalfeaturespace.Fuzzylogicsareusedtomap these input vectors.

ACuckooSearchoptimizationtechniquewhichusestooptimize the parameter of various machines learning techniquecanbeusedtoprovideenhancedperformance.Cuckoosearchworks 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 recognizedbyotherbird,iteitherthrowsthatalieneggordestroysthatnestandmakesanewone.Thispropertyisusedtooptimize the parameters of the various machines learning technique. It provides easy and simple mechanism for optimization.Ahybridtechniquewhichprovidesenhancedfunctionalitytoclassifydataispresented.Thistechniqueprovidesefficientcomputationofneural networksandfuzzylogics,andparameteroptimizationofCuckoo search technique. This technique provides enhanced classifiers to classify data. But in this technique, a neural network based techniqueisusedwhichishavingcomplexfunctionalitytoclassifydata.AsimplemachinelearningtechniquelikeKNN(K-Nearest Neighbour), SVM (Support Vector Machine) etc. technique can be used to provide enhanced classified to classifydata.

Web service composition [2] is the problem which focuses on selectinganoptimalconfigurationofthewebservicestoprovide webservicestotheuserthatsatisfiesfunctionalandnon-functionalrequirementoftheuser.Thedataoverwebincreasescontinuouslyandtherevariousserviceswhichprovidesame typeoffunctionality;toselectoptimalcompositionofthewebservicesisadifficulttasktodo.ASingletechniquewasnotabletoprovideoptimalsolution totheuserforsuchproblems.Thusahybridtechniquewhichtakes Cuckoo search and evolutionary algorithm based techniques are usedtoprovidebettersolutionfortheuseritalsousestabusearch, and reinforcement learning to provide enhanced functionality to select web services for user. In Cuckoo search artificial cuckoo areusedwhichbehavesinsamemannerasoriginalcuckoodoes. Containers id and solution associated to that container is usedto optimizethesolutionfortheproblem,previoussolutionisreplaced bythenewonetooptimizethesolution.Reinforcementlearning, evolutionary algorithm, and tabu search techniques are used to provide efficiency over time in cuckoo searchalgorithm. Stockmarket[3]isoneoftheimportantsourcesofraisingresourcesintheIndia;therearefactorslikeeconomicconditions,investor's sentiments and political events etc. which are affecting stockmarketperformance.Predictingandforecastingisoneofthemajortasksinstockmarket.Therearethreetypesofpredictionscalled short term, long term and medium term which are performed.In shorttermforecasting,predictionmaybefor10minutes,forhours orforaweek.Inmediumtermforecasting,forecastingaboutthe period of above a week or within a month is performed.Inlongtermforecastingperiodofayearorfewyearsistaken.ToperformpredictiontaskANN(ArtificialNeuralNetwork)basedtechniquesaregenerallyused.Butthesetechniquesdegradeinefficiencyovertimeandalsouseacomplex functionalitytoperformallthetasks. 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 parameteroptimization technique is used to provide better performance for the user. Cuckoo Search is parameter optimization techniqueswhichcanbeeasilytunewiththeSVMandproveanenhancedperformancetoforecastaboutthestockmarket.ACSSVM(CuckooSearchSupportVectorMachine)ispresented.Thatprovidesanenhancedfunctionalitytoforecastingaboutthestockmarketbyoptimizing the SVM classifiers. But in this technique, only factors like economic conditions, investor's sentiments, political events are takentoforecastingaboutthestockmarket.Therearesomeother factorslikegoldprice,crudeoilprice,fluctuationindollarprice are also consider to provide better forecasting.And an enhanced variantofSVMcanalsobeusedtoprovideenhancedfunctionality for forecasting.

Proteins[4] are the main constituents or building blocks for the livingorgansand DNA replication.Andalsoperformswiderangeofbiologicalfunctions.Proteinstructurepredictionisoneofthemajortasksinbioinformatics.Knowingaboutthestructureofthe protein helps in drugs design and disease prediction. Thus there are

varioustechniquessuggestedbytheresearcherstoprovidesolutiontopredictstructureoftheproteins.Acuckoosearchbased techniquewiththeABoff-latticemodelispresented.ABlattice 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 freeenergy. 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,dataclassification,imageprocessingetc.thistechniqueisusedtosolvetheproblems,wherethereisnomathematicalmodeltosolvetheproblem.FNNishavinguniversalapproximationpropertytoprovidesolutionforthevariousproblems.Thatpropertyprovidesflexibilitytodesign 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 thewholetechnique. CuckooSearchalgorithmfortheparameteroptimizationandsimplexmethodwhichprovidesolutionforthe 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 imageisrequiredtoprovidebetterperformancetodetectfingerprint.Asfingerprintsofonepersonarealwaysdifferentfromtheothers,thusalowquality imagecandegradetheperformanceofthewholetechnique.There are various technique presented by the researchers to provide an enhanced image to detect fingerprint. A high contrast image providesbetterfunctionalityascomparetothelowcontrastimage. A Cuckoo search based technique is proposed by the author to provide high contrast image for fingerprint detection. That technique enhances bothqualitativeandquantitativeenhancement in the image and reduces the noise and eradication in theimage. Cuckoo Search is a parameter optimization technique which provides easy and simple functionality to optimize parameters.Inexistingtechnique,filteringandpixelintensitybasedtechniquesareusedtoenhancethecontrastoftheimage,butthesetechniques are very time consuming. Cuckoo Search provides enhanced functionality to detectfingerprint.

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]ispresentedtoprovideanoptimalsubsetofparameterstoclassification.Thistechniqueenhancesthewholeclassification accuracy and provides accurate classifiers to classify data.Thatminimizes the classification error and reduces dimensionality of the attribute vectors.A k-nearest neighbourbased 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 ofLevydistribution.Becauselevydistributionisanormalandsimpledistributionandittakeslocationandscaleparameter andtwoshapeparameter.It doesnotgivethedesiredperformancethatisrequired.Soagamma 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 toconventional algorithm.

AHyperCubeframeworkforAntColonyOptimizationtechnique[9]ispresentedbytheauthorinthispaper.Inantcolony optimization, it is based on the behaviour of the ants during the processof finding food.Inthisprocessfirstanantsearchallaround 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 andqualityofthefood.Thispheromonehelpsotherantstofindshortestpathbetweentheirnestandfoodsource.Sametechniqueisusedwith artificial ants to find an optimized path for a given problem. Butthismethod doesnotprovideanefficientsolutionforlargescaledata.Thusahypercubeframeworkispresentedinthispaperwhich isusedtochangerulesofpheromoneupdate,inthatthevalueof the pheromone is limited for the interval of {0,1} that enhances the performance of the ant colony optimizationsystem.

ForsolvingmulticlassproblemsanovelarchitectureofSupport 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 ofboththeefficient computationofthedecisiontreearchitecture and the high classification accuracy of SVMs are taken by the proposed SVM based Binary Decision Tree architecture. The SVMBD Tarchitecture providessuperiormulti-

classclassification performance,requiresmuchlesscomputationfordecidingaclass 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 ismuchfasterthanthewidelyusedmulti-classSVMmethods likeOaO and OaA, formulticlassproblems. Theexperimentsalso show that the proposed method becomes more favourable asthe 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 outputintoprobabilities.IntheExperimentalstepsSVM+sigmoidyieldprobabilitiesarecomparedtotherawSVM,itpreservesthe sparsnessoftheSVMandalsoproducesprobabilitiesthatareofcomparable quality to the regularized likelihood kernel method. An effective way for solving multiclass problem is Binary tree supportvectormachine,whichcombinessupportvectormachine and binary trees. Structure of the binary tree relates closely to classificationaccuracyanddecisionspeedoftheclassifierAuthor

[12] proposed that, to maintain high generalization abilities, the mostseparableclassesshouldbeseparatedatuppernodesofthe 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 treeandunbalancebinarytree,theexperimentresultshowslower decision time and better accuracy with 93.59%.

Decision tree based support vector machine combines support vectormachineanddecisiontreeforsolvingmultilassproblemsinIntrusionDetectionSystemsinaneffectiveway.Thismethod increases efficiency and decreases the training and testing time of the system. In binary tree, the construction order has great influenceon the classificationperformance.Inthispaper[12]two decision tree approaches are used: Hierarchical multiclass SVM andTreestructuredmulticlassSVM.Theydividethedatasetinto two subsets from root to the leaf until every subset consist only oneclass,thusincludesdifferentwaystoconstructthebinarytrees. For measuring the separability between the classes euclidean distance is used.

DecisiontreeSVMsarchitecturewasproposedbytheauthorwhichisconstructedtosolvemulticlassproblem.By determiningoptimalstructureofdecisiontreeusingstatisticalmeasuresforobtainingclassseparability,thispaper[14]maintainhighgeneralizationabilities.Advantageofboththehigherclassificationaccuracyof SVM and efficient computation of decision tree architecture are taken by Optimal decision tree (ODT-SVM). A non-parametric testiscarriedoutovermultipledatasetsforstatisticalcomparison of proposed ODT-SVM with other classifiers. Performance is evaluatedintermsofcomputationtimeandclassificationaccuracy. 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 andOaA.

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) usesposteriorprobabilityestimatesofbinarySVMoutputstoaim at increasing the classification speed of OAA. When compared toOAAandothermulticlassSVMmethods,theaveragenumber of binary SVM tests required in testing phase is decreased to a greater extent in DTOAA. DTOAA requires only (K + 1)/2 binarytestsonanaverageascomparedtoKbinarytestsinOAA in a balanced multiclass dataset with K classes; however,onimbalancedmulticlassdatasets,DTOAAisobservedtobemuchfasterwithproperselectionoforderinwhichthebinarySVMsare 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 decisionmaking.

Theexistingbinaryclassifiertechniquesrunintoseriousefficiency 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 tothisproblem.Authorintroducestheconceptofcorrelationand jointpro babilityof basebinarylearners.Duringthetrainingstagewelearntheseproperties,andgroupthebinarylearner'sbasedontheirindependence,combinetheresultsusingaBayesianapproach to predict the class of a new instance. Lastly, we discusstwoadditionalstrategies:oneistoreducethenumberofbaselearnersrequiredinthemulticlassclassification,andsecondistofindnew base learners, that might be best for the existing set. These two new procedures are used iteratively to complement the initial solutionandimproveoverallperformance.Thehighestaccuracy achievedis96%.Thetwogoalsare:tofindthemostdiscriminative binary classifiers to solve a multiclass problem and keep up the efficiency, i.e., small number of baselearners.

Inthispapertheauthors[17]proposeandexaminetheperformance of a framework, for solving multiclass problems withSupportVectorMachine(SVM).TheproposedmodelbuildsabinarytreeformulticlassSVM,usingthetechniqueofpartitioningbycriteria ofnaturalclassificationi.e.SeparationandHomogeneity,aiming to obtain optimal tree.

However, the main result is the mapping ofthemulticlassproblemintoaseveralbi-classessubproblems, inordertoeasetheresolutionoftherealandcomplexproblems. In the construction of the tree our approach is more accurate.Further,inthetestphaseOVATreeMulticlassismuchfasterthanothermethodsinproblemsthathavebigclassnumber,duetoits Log complexity. In this context, to evaluate our framework two corpusareused;oneisTIMITdatasetsforclassificationofvowel andMNISTforhandwrittendigitsrecognition.Arecognitionrateachievedwas57%onthe20vowelsofTIMITcorpusand 97.73% on the 20 digits of MNIST datasets. Also the number of support vectors and training time, which mainly determines theduration 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/OVAstrategies.Generally,thetreebaseSVMclassifierstrytosplitthemulticlassspaceintoseveralbinarypartitions ,bysomeclustering 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] presentsapreliminaryandpromisingresultofamulticlassspacepartitioningmethodthataccountsfordatabaseclassstructureand allowsnode‘sparameterspecificsolutions.Thespaceissplitinto 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.

Inthispaper,author[19]presentsanovelarchitectureofSupport 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 highclassificationaccuracyofSVMsandtheefficientevaluation of the decision tree architecture are taken by the proposed SVM based Binary Decision Tree architecture. To provide superior multi-classclassificationperformancetheSVMBDTarchitecture was designed. Its performance was evaluated on samples from MNIST,Pendigit,OptdigitandStatlogdatabasesofhandwritten 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.Duringrecognitionphase,SVM-BDTismuchfaster than the widely used multi-class SVM methods like OAO (one- against-one)andOAA(one-againstall)duetoitslogarithmiccomplexity,formulticlassproblems.Theexperimentalsoshowsthattheproposedmethodbecomesmorefavourableastheincrease in number of classes in the recognition problem.

The authors [20] describe an original classification technique, the Probabilistic Decision Tree (PDT) producing aposterioriprobabilitiesinamulticlasscontextinthispaper.ThisisbasedonaBinaryDecisionTree(BDT)withProbabilisticSupportVector Machineclassifier(PSVM).Ateachnodeofthetree,abi-classSVM are trained along with a sigmoid function to give a probabilistic classification output. The outputs of all the nodes composing thebrancharecombined,toleadtoacompleteassessmentofthe probability when reaching to the final leaf. To demonstratetheeffectivenessofPDTs,testingisdoneonbenchmarkdatasetsandresultsarecomparedwiththeotherexistingmethods.Thehighest accuracyachievedis92.75%whencomparedtoothermulticlass methods, such as OvO, DAG,RL-BDT.

III. Conclusion

Classificationisoneofthemajortasksindataminingwhichisusedtoprovideenhancedfunctionalityandextractusefulinformationfromthedata.Selectionoftheparametersputshugeimpactovertheperformanceoftheclassifiers.Therearevariousoptimization techniqueswhichcanbeusedtooptimizetheperformanceofthe classifiers to classify data. A review over the technique which used Cuckoo search algorithm to optimize the performance of theclassifiersispresentedinsectionIILiteratureReview,which shows Cuckoo search is an enhanced and easy to tune with the other technique, to provide optimized classifiers to classify the data.Forfuturework, ahybrid techniqueisusedwhichusesBDT- SVM and Cuckoo Search to provide an enhanced mechanism to classify the data.

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