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A Comprehensive Review of Data Mining Rules Generation Algorithms

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Abstract
These days, mining and extracting data from wide range of information is required by the companies or organisations. For completing this process Knowledge Discovery Databases KDD is the appropriate method. This process will help to mine, extract, analyse and visualize the information in appropriate format. But there are various algorithms or techniques are available to perform decision making process such as pattern finding, clustering, Apriori, classification, time series, prediction etc. Optimization is the prominent method these days' researchers are using for finding the secondary data.
Keywords: Data mining, Clustering, Association Rule Mining, Classification, Genetic Algorithm**.**

1. Introduction

Data storage requirement is increasing rapidly with use of ICT information and communication technologies. Due to which requirement of extracting the information is also increasing day by day. Analyst require correct technique to for mining the relevant data. Data mining is a useful and important technique that helps for decision making through finding the hidden information and patterns. There are various algorithms available such as Apriori, FP tree clustering, classification, prediction and so [1]. Mining information helps company to find the user interest [1][54][55][56]. Traditionally, mining rules based on using threshold values such as minimum support and minimum confidence would help in getting better rules and mining large datasets. In order to enhance the efficiency of the rules and to reduce the complexity other algorithms or optimized algorithms can be used such as Genetic Algorithm, Genetic Programming, PSO, Ant colony optimization. Clustering, classification, regression models, summarization are various algorithms or technique what user can use to fetch appropriate rules [2]. Genetic algorithm including different chromosome conclude giving comprehensive rules [3] genetic algorithm and clustering hybrid technique could also be used for finding efficient rules [4]. Genetic algorithm and PSO is used to develop a global association rule. The population is formed for each generation maximizing the sample set.

2. Rule Mining Techniques

To mine the association rules numbers of algorithm are being introduced. The basic algorithm for association rule mining is Apriori Algorithm. Apriori algorithm is used to operate on databases containing transactions. Many improved Apriori algorithm was introduced. Apriori was implemented with different data structures like hash, trees, link list and etc.
Following are the various algorithms for association rule mining:

Apriori Algorithm

The Apriori algorithm is a classical association rule mining [1][54][55][56]. The algorithm starts with a dataset containing transactions and generates frequent item sets, having at least a user specified threshold. In the

algorithm of Apriori, an item set X of length k is frequent if and only if every subset of X, having length k _ 1, are also frequent. Apriori supports downward closure.

Classification technique combined with Genetic algorithm

The classification task is one of the most studied in data mining.[3]. the GA's individuals (or chromosomes) encode IF-THEN classification rules, similarly (in form) to the rules discovered. Author used specific fitness function with two parameters': sensitivity and specificity [3]

Genetic algorithm with clustering

A genetic algorithm-based clustering algorithm, called GA-clustering. Genetic algorithm has been used to search for the cluster centres which minimize the clustering metric [4][57]. The searching capability of GAs has been used for the purpose of appropriately determining a fixed number K of cluster centers in RN; thereby suitably clustering the set of n unlabeled points. The results show that the GA-clustering algorithm provides a performance that is significantly superior to that of the K-means algorithm [4][8]

Classification with Genetic programming

In GP, the basic idea is the evolution of a population of "programs", i.e., candidate solutions to the specific problem in hand. A program (an individual of the population) is usually represented as a tree, where the internal nodes are functions (operators) and the leaf nodes are terminal symbols. More complex representations, like graphs, are unusual since they require specialized genetic operators. Both the function set and the terminal set must contain symbols appropriate for the target problem. The function set can contain arithmetic operators, logic operators, mathematical functions, etc; whereas the terminal set can contain the variables (attributes) of the problem.[5]. The use of genetic programming (GP) for discovering comprehensible classification rules, in the spirit of data mining, is a relatively underexplored area. [5]

Association rule mining and Genetic Algorithm

The genetic algorithm (GA) is an evolutionary computation algorithm, introduced and investigated by the scientist John Holland and one of his students at the University of Michigan at the beginning of the 60s [22][57] In Genetic algorithm is inspired by the principles of genetics and evolution, and mimics the reproduction behaviour observed in biological populations. It belongs to stochastically search algorithm bases on principles of natural selection and recombination. [6][9]

Working principle of Genetic Algorithm

Step I [Start] Generate random population of chromosomes, that is, suitable solutions for the problem.

Step II [Fitness] Evaluate the fitness of each chromosome in the population.

Step III [New population] Create a new population by repeating following steps until the new population is complete.

a) [Selection] Select two parent chromosomes from a population according to their fitness. Better the fitness, the bigger chance to be selected to be the parent.

b) [Crossover] With a crossover probability, cross over the parents to form new offspring, that is, children. If no crossover was performed, offspring is the exact copy of parents.

c) [Mutation] With a mutation probability, mutate new offspring at each locus.

d) [Accepting] Place new offspring in the new population.

Step IV [Replace] Use new generated population for a further run of the algorithm.

Step V [Test] If the end condition is satisfied, stop, and return the best solution in current population.

Step VI [Loop] Go to step 2. [4]

Non-Dominated Sorting Genetic Algorithm (NSGA)

Non-Dominated Sorting Genetic Algorithm (NSGA) with accuracy and coverage measure. The objective was to propose the use of multi-objective optimisation evolutionary algorithms to allow the user to interactively select a number of interest measures and deliver the best nuggets. They used Adult, Mushroom, and Contraception data set. There outcome is to develop a novel approach with a number of interest measures which may be selected and then to search for a set of solutions which represent an approximation to the pareto optimal.[7]. Author develop a new approach with a number of interesting measures that can be chosen and then search for a set of solutions that represent an optimal approximation to the pareto.

NLP with text mining

A new concept-based mining model that relies on the analysis of both the sentence and the document, rather than, the traditional analysis of the document dataset only is introduced[50][51]. The proposed mining model

consists of a concept-based analysis of terms and a concept-based similarity measure. The term which contributes to the sentence semantics is analysed with respect to its importance at the sentence and document levels. The model can efficiently find significant matching terms, either words or phrases, of the documents according to the semantics of the text. The similarity between documents relies on a new concept-based similarity measure which is applied to the matching terms between documents. Experiments using the proposed concept-based term analysis and similarity measure in text clustering are conducted. [10]. a genetic algorithm (GA) as a search strategy for not only positive but also negative quantitative association rule (AR) mining within databases. Contrary to the methods used as usual, ARs are directly mined without generating frequent itemset. The proposed GA performs a database-independent approach that does not rely upon the minimum support and the minimum confidence thresholds that are hard to determine for each database [11].

Rule mining with all operators (<=,>=, ! =,=)

Most methods for mining association rules from tabular data mine simple rules which only represent equality in their items. Limiting the operator only to "=" results in many interesting frequent patterns that may exist not being identified. It is obvious that where there is an order between objects, greater than or less than a value is as important as equality. This motivates extension, from simple equality, to a more general set of operators. We address the problem of mining general association rules in tabular data where rules can have all operators $\{\leq,>,\neq,=\}$ in their antecedent part. The proposed algorithm, Mining General Rules (MGR), is applicable to datasets with discrete-ordered attributes and on quantitative discretized attributes. The proposed algorithm stores candidate general itemsets in a tree structure in such a way that supports of complex itemsets can be recursively computed from supports of simpler itemsets. The algorithm is shown to have benefits in terms of time complexity, memory management and has great potential for parallelization. [16]

Multi-Objective Genetic algorithm

A novel multi-objective genetic algorithm (GA)-based rule-mining method for affective product design is proposed to discover a set of rules relating design attributes with customer evaluation based on survey data. The proposed method can generate approximate rules to consider the ambiguity of customer assessments. The generated rules can be used to determine the lower and upper limits of the affective effect of design patterns. For a rule-mining problem, the proposed multi-objective GA approach could simultaneously consider the accuracy, comprehensibility, and definability of approximate rules. In addition, the proposed approach can deal with categorical attributes and quantitative attributes, and determine the interval of quantitative attributes. Categorical and quantitative attributes in affective product design should be considered because they are commonly used to define the design profile of a product. [21]

Rule mining with parallel genetic-fuzzy mining framework

To optimize the rules generated by Association Rule Mining using Biogeography Based Optimization (BBO). BBO has a way of sharing information between solutions depending on the migration mechanisms. [27]

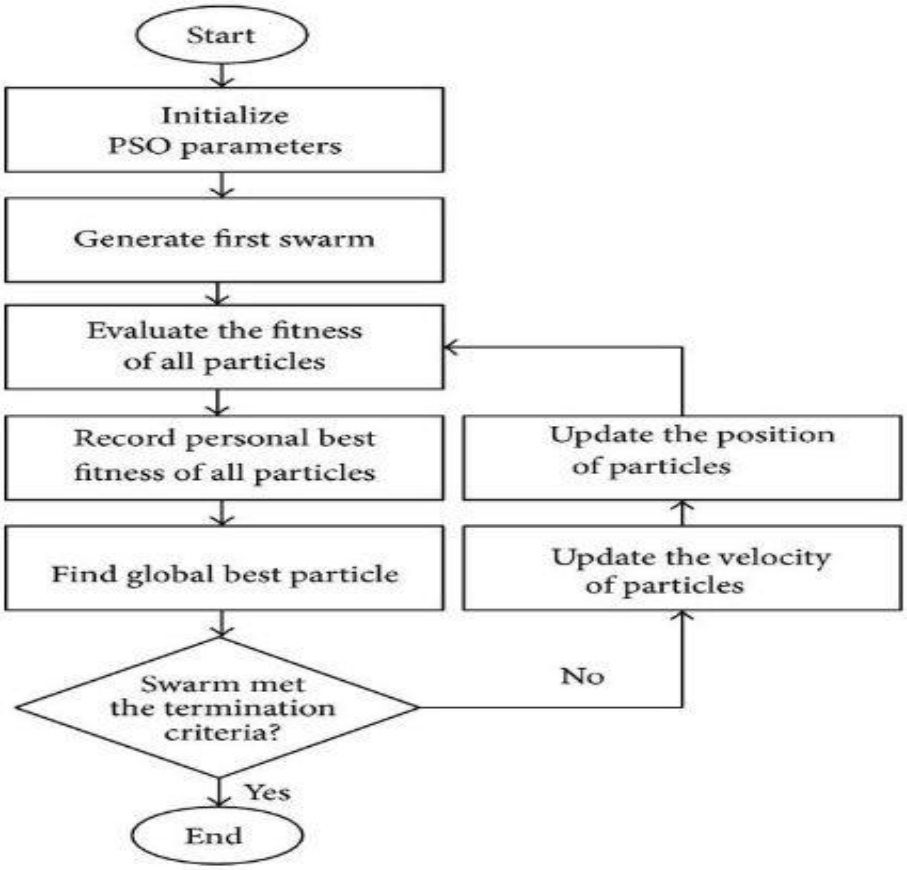
Genetic algorithm with PSO

The Particle Swarm Optimization (PSO) algorithm is a computational optimization method, which is based on the social behaviour of living organisms such as fishing schooling, bird flocking[57]. The Particle Swarm Optimization algorithm was first designed in 1995 by the scientists Kennedy and Eberhart [28][40] base on the social learning and social psychological model of birds seeking food, each bird is an agent in the search space, during the food search time, swarm agents are cooperating with other agents around it to find food.

Particle swarm optimization (PSO) is a computational method that is used in computer science field to optimize problem solution by iteratively improvement of a candidate solution among a set of solutions with regard to a given measurement of fitness quality [30[55][56]. Such methods are commonly known as meta-heuristics methods PSO shares much dissimilarity with evolutionary computation techniques such as Genetic Algorithms (GA) [30][40][53][54]. The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called *pbest*. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbors of the particle. This location is called *lbest*. When a particle takes all the population as its topological neighbors, the best value is a global best and is called *gbest* [39][40][51][52]

PSO operations [40]

The following are the steps of the PSO algorithm that briefly summaries the working of PSO.



PSO is initialization-based algorithm, with set of random solutions and continue with searching for optimal values through multiple iterations or generations. Each particle is updated with continue two best values. “pbest” is the best solutions and “gbest” is global best solution. The global best and personal best is saved into the memory and continue till it gets the best outcomes. [40][49][50]

Fuzzy with genetic algorithm

It is a novel AGAFL classifier for classifying heart disease datasets[48][49][50]. AGAFL has three steps:

1. reduction of features/dimensions utilizing rough sets
2. generating rules from the reduced dataset through the application of Fuzzy Logic Classifier
3. optimizing generated rules through the application of Adaptive Genetic Algorithm.

The latter utilizes a fitness function for optimizing the rules generated through Fuzzy Logic Classifier. The major contributions of the proposed model are as follows:

• Rough set theory to identify most relevant features as Rough Set theory is an effective tool to deal with vagueness and uncertainty information to select the most relevant attributes for a decision system.

• Adaptive Genetic Algorithm to optimize the classification rules, to achieve better accuracy, reduce time complexity [41][46][47]

Hybrid ANN, PSO, GA

A method, named smart HGP-FS utilizes artificial neural network (ANN) in the fitness function. The filter and wrapper methods are integrated in order to take the benefit of filter technique acceleration and the wrapper technique vigour for selection of dataset efficacious characteristics. Some dataset characteristics are eliminated through the filter phase, which in turn reduces complex computations and search time in the wrapper phase. Comparisons have been made for the effectiveness of the proposed hybrid algorithm with the usability of three hybrid filter-wrapper methods, two pure wrapper algorithms, two pure filter procedures, and two traditional wrapper feature selection techniques. The findings obtained over real-world datasets show the efficiency of the presented algorithm [44]

3. Discussion and future research distribution:

This study is done to access the influence of different rule mining techniques. A comprehensive review of research papers in this study provides an overview of the way different algorithm mine the rules. The articles

considered for review in this study are from the year 2000 to the year 2021.

Table1: The distribution of rule mining methods by year.

2000-2005	**2005-2010**	**2010-2015**	**2015-2020**	**2021**
classification with genetic algorithm	NLP with text mining	Genetic algorithm	PSO	KNN-GA
Clustering	classification	Evolutionary algorithm	Genetic algorithm	-
clustering with support and confidence	genetic algorithm	Genetic algorithm	Cluster and genetic algorithm	-
-	Using operators(<=,>=,!=,=)	Biogeography based optimization (BBO)	Clustering	-
-	AVI algorithm	Genetic-Fuzzy algorithm	GA-PSO	-
-	-	PSO with association rule mining	ANN,GA,PSO	-
-	-	Genetic Programming	-	-

Table 2: Year wise algorithm used

Algorithm/Year	2000-2005	2005-2010	2010-2015	2015-2020	2021
classification	Yes	Yes			
classification with genetic algorithm					
clustering	Yes			Yes	
clustering with support and confidence	Yes				
Clustering with genetic algorithm				Yes	
NLP		Yes			
Genetic algorithm		Yes	Yes	Yes	
AVI algorithm		Yes	Yes		
evolutionary algorithm			Yes		
Genetic -Fuzzy					
PSO				Yes	
PSO association rule mining			Yes		
genetic Programming			Yes		
KNN, GA, PSO				Yes	
KNN and genetic algorithm					Yes

In Table 2, it has been concluded that genetic algorithm is most commonly used algorithm for rule mining but few researchers have also used other techniques such as clustering, classification, PSO, KNN and so.

4. Conclusion

It has been observed that combination of support, confidence, lift, leverage and conviction may be used to evaluate the interestingness. So, there is a scope of using such measures to generate appropriate rules. Considering more metrics, such as amplitude, may obtain better rules. Therefore, these metrics can be used for better results. Performance may be improved by eliminating the need to determine the extents of the threshold for the criteria of support and confidence.[39]. Many models have not used algorithms with categorical datasets.[28]. So, this may add some scope of the research. It has been indicated that increase in support value may give more appropriate rules.[28]. Thus, there is some scope to enhance the efficiency of the rules. Hybrid metaheuristics also should be evaluated to generate better rules.[39]. Future works may involve the use of other machine-learning classification algorithms or employing other population-based feature selection meta-heuristics and compare their performances to the one obtained by the proposed approach.

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