APPLICATIONS OF CLUSTERING TECHNIQUES IN DATA MINING: METHODS AND INNOVATIONS

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ABSTRACT:
In modern scientific research, data analyses are often used as a popular tool across computer science, communication science, and biological science. Clustering plays a significant role in the reference composition of data analysis. Clustering, recognized as an essential issueofun supervised learning, deals with the segmentation of the data structure in an unknown region and is the basis for further understanding. Among many clustering algorithms, "more than 100 clusteringalgorithmsknown"becauseofitssimplicityandrapidconvergence,the K-means clustering algorithm is commonly used. This paper explains the different applications, literature,challenges, methodologies, considerations of clustering methods,and related key objectives to implement clustering with big data. Also, presents one of the most common clustering techniques for identification of data patterns by performing an analysis of sample data.

Keywords *- Clustering;dataanalysis;datamining;unsupervised learning;k-mean;algorithms.*
DOI Number: 10.48047/NQ.2023.21.3.NQ33044 **Neuroquantology 2023; 21(3):405-410**

1. INTRODUCTION

Data mining is the latest interdisciplinary field of computational science. Data mining is the process of discovering attractive information from large amounts of data stored either in data warehouses, databases, or other information repositories. It is a process of automatically discovering data pattern from the massive database. Data mining refers to the extraction or "mining" of valuable information from large data volumes. Nowadays, people come across a massive amount of information and store or represent it as datasets. Process discovery is the learning task that works to the construction of process models from event logs of information systems. Fascinating insights, observable behaviours, or high-level information can be extracted from the database by performing data mining and viewed or browsed from various angles. The knowledge discovered can be applied for process control, decision making, information management, and question handling. Decision-makers will make a clear decision using these methods to improve the real problems of this world further. In data mining, many data clustering techniques are used to trace a particular data pattern. Data mining methods for better understanding are shown in Fig. 1.

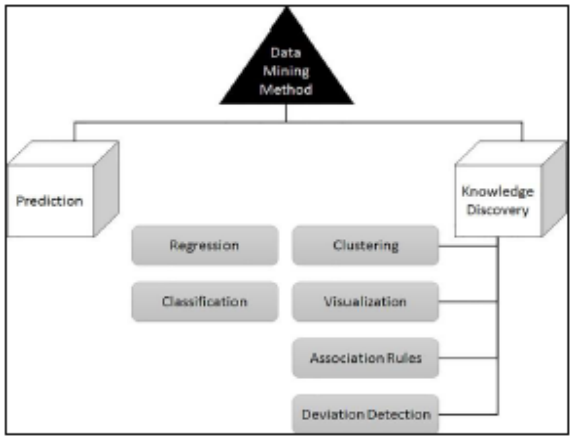

Fig. 1. Methods of Data Mining Techniques.

Clustering techniques are useful meta-learning tools for analyzing the knowledge produced by modern applications. Clustering algorithms are used extensively not only for organizing and categorizing data but also for data modelling and data compression. The purpose of the clustering is to classify the data into groups according to data similarities,traits, characteristics, and behaviours. Data cluster evaluation is an essential activity for finding knowledge and for data mining. The process of clustering is achieved by unsupervised, semi-supervised, or supervised manner. However, there are more than 100 clustering algorithms known and selection from these algorithms for better results is more challenging.

Clustering in Data Mining

Data volumes continue to expand exponentially in various scientific and industrial sectors, and automated categorization techniques have become standard tools for data set exploration. Automatic categorization techniques, traditionally called clustering, helps to reveal a dataset‟s structure. Clustering is a well-established unsupervised data mining-based method, and it deals with the discovery of a structure in unlabeled data collection. The overall process that will be followed when developing an unsupervised learning solution can be summarized in the following chart in Fig. 2:

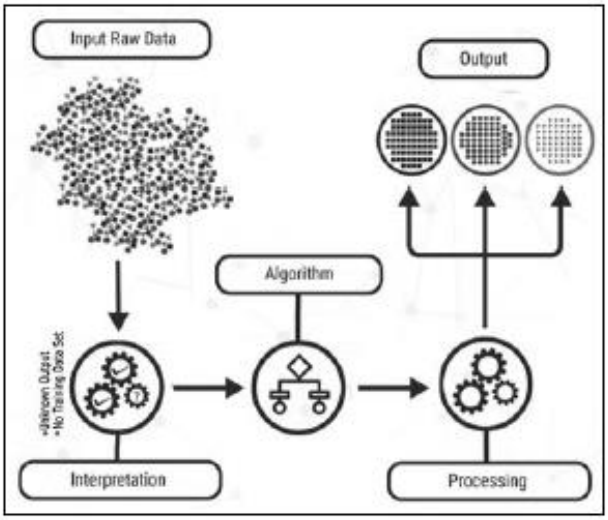

Fig. 2. Unsupervised Learning Model

The main applications of unsupervised learning are:

- Simplify datasets by aggregating variables with similar attributes.
- Detecting anomalies that do not fit any group.
- Segmenting datasets by some shared attributes.

Clustering results in the reduction of the dimensionality of the data set. The objective of such a clustering algorithm is to identify the distinct groups within the data set. There are different clustering objects, such as hierarchical, partitional, grid, density-based, and model-based. The performance of various methods can differ depending on the type of data used for clustering and the volume of data available. For example, Document clustering has been investigated for use in many different areas of text mining and information retrieval. There are several different metrics of quality, relative ranking, and the performance of different clustering algorithms that can vary considerably depending on which measure is used. Two measures of “goodness” or quality of the cluster are used for clustering. One type of measure allows comparing different cluster sets without external knowledge and is called an “internal quality measure.” The other form of measure is called an “external quality measure,” which allows evaluating how well the clustering works by comparing the groups generated by the clustering techniques to the classes identified. Fig. 3 shows a simple example of data clustering based on data similarity.

Types of clustering: Clustering can generally be broken down into two subgroups:

Hard Clustering: In hard clustering, each data point is either entirely or not part of a cluster. For example, each customer is grouped into one of 10 groups.

Soft Clustering: In soft clustering, a probability or likelihood of the data point being in certain clusters is assigned instead of placing each data point into a separate cluster. For example, each customer is assigned a probability to be in 10 clusters.

Clustering methodologies: Since the clustering method is subjective, it is the tool that can be used to accomplish plenty of objectives. Every methodology follows several sets of rules and regulations that describe the „similarity‟ between data points. Cluster analysis is not an automated task, but an iterative information discovery process or multi-objective

collaborative optimization involving trial and error.

The best known and most widely used method of partitioning is K-means. There are many clustering techniques from which K-means is an unsupervised and iterative data mining approach. The standard approach of all clustering techniques is to classify cluster centres representing each cluster. K-means clustering is a method of cluster analysis aimed at observing and partitioning data point into k clusters in which each observation is part of the nearest mean cluster. The most significant advantage of the K-means algorithm in data mining applications is its efficiency in clustering large data sets. K-means and its different variants have a computation time complexity that is linear in the number of records but is assumed to discover inferior clusters.

The K-means algorithm is a basic algorithm for iterative clustering. It calculates the distance means, giving the initial centroid, with each class represented by the centroid, using the distance as the metric and given the classes K in the data set. In the k-means partitioning algorithm, the mean value of objects within-cluster is represented at the centre of each cluster.

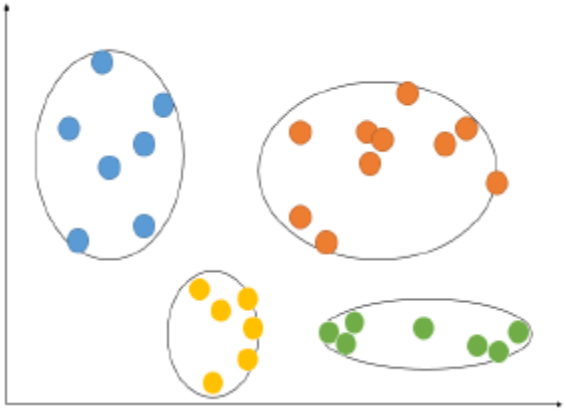

Fig. 3. Simple Clustering Example

2. BACKGROUND AND DISCUSSION OF CLUSTERING APPLICATIONS AND APPROACHES

Cluster analyses have lots of applications in different domains, e.g., It has been popularly used as a preprocessing step or intermediate step for other data mining tasks “Generating a compact summary of data for classification, pattern discovery, hypothesis generation and testing, compression, reduction, and outlier detection, etc.” Clustering analysis can also be used in collaborative filtering, recommendation systems, customer segmentation, multimedia data analyses, biological data analyses, social network analysis, and dynamic trend detection.

Requirement and Challenges

Despite recent efforts, the challenge of clustering on “mixed and categorical” data in the sense of big data remains, due to the lack of inherently meaningful similarity measurement between the high computational complexity of current clustering techniques and categorical objects. For cluster analysis, there are several items to be considered.

- As a stand-alone tool to get insights into data distribution.
- As a preprocessing (or intermediate) steps for other algorithms.

According to, parallel classification is a better approach for big data, but due to its implementation’s complexity remains a significant challenge. However, the framework of MapReduce can be suitable for implementing parallel algorithms, but still, there is no algorithm to handle all Challenges of big data. In, the authors proposed a novel Spark extreme learning machine “SELM” algorithm based on a spark parallel framework to boost the speed and enhance the efficiency of the whole process. SELM gives the highest speed and minimal error in all experimental results compared to Parallel Extreme Learning Machine (PELM) and an improved Extreme Learning Machine (ELM*).

3. RUNNING EXAMPLE WITH K-MEAN

A car manufacturer company wants to identify the purchase behaviours of its customers to view which product is getting more sales and what is the procedure of our customers. They are currently looking at each customer‟s details based on this information, decide which product manufacturing should be increased and what are the behaviour of customers which helps the company to monitor sales for other products by starting a promotional campaign or increase the availability of resources.

Recently, the company can potentially have millions of customers. It is not possible to look at each customer‟s data individually and then make a decision. A manual process will take a huge amount of time. This is when K-means Clustering assists in a convenient way to analyze data automatically. The K-mean clustering algorithm utilizes a fixed number of

clusters for optimum clustering. Initially, start partitioning with the chosen number of clusters next to improve the partitions iteratively to find the patterns in data. Let D= {D1, D2, …, Dn} be the set of data points and Y= {Y1, Y2, …, Yt} be the set of centers. This clustering technique is implemented and analyzed using a k-mean clustering tool WEKA. In the following steps, the K-means algorithm can be implemented:

K-mean Clustering Algorithm

1. The first step in k-means is to pick the number of clusters, k.
2. Randomly select k number of clusters centre.
3. Find the distance between each data point and each cluster centre.
4. In contrast with other cluster centres, assign the data point to the nearest cluster centre.
5. Discover the new Cluster Centre again $Y_i = \sum_{i=0}^{ki} D_i$ by where k_i represents number of data points in i^{th} cluster.
6. Once again, find out the distance between each data point and the new cluster centre.
7. If no data points were reassigned then stop, otherwise back to step 3.

The data set used for the K-mean clustering example will focus on a fictional car dealership. The dealership is starting a promotional campaign for slow-selling units, whereby it is trying to push resources to its valuable customers.

Customers went to the dealership without going on a showroom and done some computer search mostly interested in Toyota Harrier without financing they purchased it. These types of behaviour understandings about customers help Toyota to manage their sales. K-mean clustering allows the company to perform analysis without any efforts by finding patterns in a given dataset, shown in Fig. 4 and Fig. 5.

Fig. 4 explains that based on cluster 3, 100% of customers went for the dealership, whereas 45% went to the showroom too, and 100% of the customers also did computer searching. The majority of the customer that is 63% have shown interest in Fortuner, whereas 45% had shown interest in Harrier, and the least interest was found to be 9% in Corolla. These customers who 100% end up financing and purchasing a product consistently went to the dealership and done computer searching before buying an SUV car.

Meanwhile, based on cluster 4, only 32% of customers went to the dealership, whereas 100% went to the showroom, and 24% also did computer searching. Majority of the customers that are 100% interested in Corolla whereas 32% had shown interest in Fortuner, and the least interest was found to be 3% in Harrier; out of all these, 56% of the customers went for the financing details whereas 82% ends up purchasing a product. These are the customers looking for a small family car, i.e., Corolla, mostly approaching the showrooms.

		Cluster#				
Attribute	Full Data	0	1	2	3	4
	(100.0)	(19.0)	(35.0)	(10.0)	(11.0)	(25.0)
Dealership	0.59	1	0.3429	0.9	1	0.32
Showroom	0.7	0.4211	0.8857	0.1	0.4545	1
ComputerSearch	0.41	0.7895	0.0857	0.6	1	0.24
Harrier	0.65	0.2105	1	1	0.4545	0.03
Corolla	0.41	0.3158	0	0.9	0.0909	1
Fortuner	0.61	0.4737	0.8286	0.8	0.6364	0.32
Financing	0.48	0.2105	0.3429	0.7	1	0.56
Purchase	0.39	0	0.4857	0.2	1	0.82

Fig. 4. Customers Purchase Behaviours

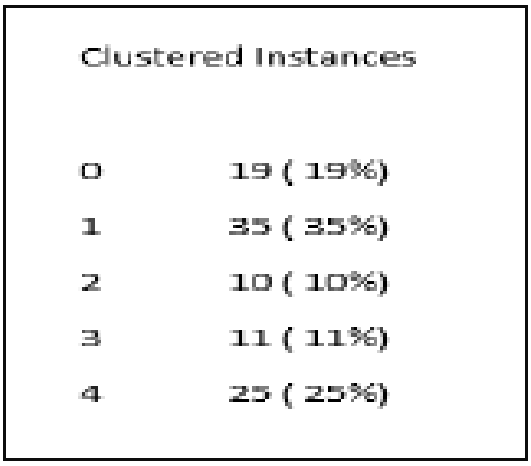

Fig. 5. Clustered Instances based on Customers Behaviour.

5. CONCLUSION AND FUTURE SCOPE

This paper describes the different algorithms and methodologies used to handle large and small sets of data. The process of clustering is to group data based on their characteristics and similarities. Previously described the clustering models, many clustering techniques used to partition the data into a set of clusters. Algorithm selection should depend on the properties and the nature of the data collection because each algorithm has its pros and cons. This shows that there is no algorithm to manage all the clustering challenge. However, there are some algorithms to provide an optimist solution based on their sufficiency to face the challenges of the problem. To achieve high accuracy in terms of time and space, K-means would be the best choice for large and categorical data. However, we need to reduce their time and memory‟s complexity by upgrading Clustering Algorithms. However, a combined approach of the Genetic Algorithm with K-means can almost resolve all the issues of K-means. Genetic K-means Algorithm (GKA) speeds up the convergence to a globally optimum, and it concludes that GKA is faster than evolutionary Algorithms.

FUTURE DIRECTIONS AND OPEN ISSUES

To date, Data Mining and information disclosure are advancing an essential innovation for businesses and scientists in numerous domains. Although information mining is extremely powerful, it faces innumerable difficulties during its usage. The problems could be identified with performance, data, strategies, and procedures utilized. The information mining measure becomes effective when the challenges or issues are distinguished accurately and sifted through appropriately.

Some of the following challenges and future directions are:

Efficiency and Scalability of Algorithms: The data mining algorithms must be proficient and adaptable to extricate data from gigantic sums of information within the database. So, as a future direction, develop a parallel formulation of an Improved rough k-means algorithm to enhance the efficiency of an algorithm.

Privacy and Security: Information mining ordinarily leads to genuine issues in terms of information security, protection, and administration. For case, when a retailer reveals his clients purchasing details without their permission. So, as a future direction, there needs to develop a single cache system and DES (Data Encryption Standard) techniques in any Clustering Algorithm to improve the privacy and security of data in the cloud.

Complex Data Types: Complex data elements, objects with graphical data, temporal data, and spatial data may be included in the database. Mining of these types of data isn't practical to be done one device.

Performance: The execution of the data mining framework depends on the proficiency of calculations and procedures are utilizing. The calculations and strategies planned are not up to the marked lead to influence the performance of the data mining process. Therefore, as a future direction, we need to introduce a new hybrid approach of an Improved Rough k-means Algorithm, and the Genetic Algorithm will improve the performance and handles the complex data. The combination of Partitioning Clustering and Hierarchical Clustering Algorithms will also increase the accuracy of data analysis.

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