Evaluation of h- and g-indices of Scientific Authors using Modified K-Means Clustering Algorithm

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ABSTRACT

In this paper we proposed modified K-means algorithm to assess scientific authors performance by using their h,g-indices values. K-means suffers from poor computational scaling and efficiency as the number of clusters has to be supplied by the user. Hence, in this work, we introduce a modification of K-means algorithm that efficiently searches the data to cluster points by compute the sum of squares within each cluster which makes the program to select the most promising subset of classes for clustering. The proposed algorithm was tested on IRIS and ZOO data sets as well as on our local dataset comprising of h- and g-indices, which are the prominent markers for scientific excellence of authors publishing papers in various national and international journals. Results from analysis reveal that the modified k-means algorithm is much faster and outperforms the conventional algorithm in terms of clustering performance, measured by the data discrepancy factor.

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1. INTRODUCTION

The existence of journals to publish scientific research or reviews on a specified topic has been in place since many years, which raised the alarm to build databases to disseminate literature information to everyone [1]. The number of papers published in journals that have been increased from many years and that can be affiliated on account of their citations by scientists worldwide. The constant and increased volume of scientific literature and the assortment of inter-disciplinary fields of science have created wealth of knowledge useful to many scientists [2]-[3] which intend to solve many problems. At the same time, the scientific field has also seen a gradual increase in the number of open access journals that publish specific streams of study [4]-[5]. The best possible way to evaluate any journal is to follow the number of citations with respect to the number of papers published in a year, which is referred as Impact Factor [6]. Similarly, considering the importance of authorship of any work being cited by other works, h-index has been introduced by Hirsch [7], [16]. This h-index evaluates the score generated from the papers published by the specific author as well as the number of papers published since the first publication [8]. However, h-index does not consider the specific field of work, for instance, an author might publish papers on ‘text mining’, ‘computer architecture’, ‘networking methods’ etc. In such case, h-index is given for all papers published by the author but not related to a specific field [9]. The *h* index is mostly used to measure the scientific achievement for individual researchers, and also to measure the scientific output of research groups. However, in order to give more weight to highly cited articles. Leo Egghe says the g-index [10].

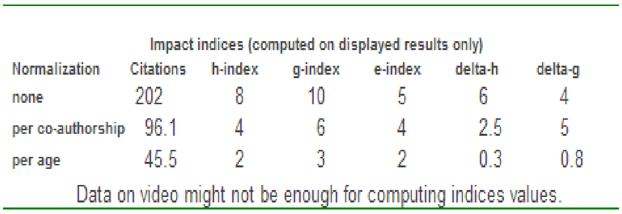
K-means clustering is an iterative clustering procedure and it works as a greedy algorithm for partitioning the n samples into k clusters and predefines the number of clusters. The algorithm begins by defining centroids, which are points in the dataset that eventually appear at the center of each cluster. A very common task in data analysis is that of grouping a set of objects into subsets such that all elements within a group are more similar among them than they are to the others. K-means suffers from poor computational scaling and efficiency as the number of clusters has to be supplied by the user. Therefore, the primary objective of this study is to calculate h- and g-indices of authors and cluster them using modified K-means algorithm and compare the efficiency with conventional k-means clustering algorithm [10]. Hence, in this paper, we introduce a modification of K-means algorithm that efficiently searches data to cluster points by compute the sum of squares within each cluster, which makes the program to select the most promising subset of classes for clustering.

The h- and g- indices of few authors who have published scientific papers of excellence in the fields of computer science [11] are segregated. In order to collect and calculate manually, a reliable tool from Google Scholar [12] was used to perform the task. Google Chrome has developed an intuitive H-index calculator add-on to Chrome browser.

2. MATERIALS AND METHODS

2.1. h- and g-indices

The h- and g- indices of few authors who have published scientific papers of excellence in the fields of computer science are segregated. In order to collect and calculate manually, which is a more tedious process than expected; a more reliable tool from Google Chrome was used to perform the task. Google Chrome has developed an intuitive H-index calculator add-on.



Impact indices (computed on displayed results only)

Normalization	Citations	h-index	g-index	e-index	delta-h	delta-g
none	202	8	10	5	6	4
per co-authorship	96.1	4	6	4	2.5	5
per age	45.5	2	3	2	0.3	0.8

Data on video might not be enough for computing indices values.

Figure 1**.** Index values computed by the calculator

Both the h- and g-indices are consequence to some scope by the number of papers published in a journal. A journal that publishes a larger number of papers has a higher possibility to make a higher h- and g-indices since every article presents another chance for citations [16]. The value for the indices depends on the range of papers being examined, and how comprehensively the citations for each have been indexed. The main intensity of the h-index is that it measures quantity and impact by the means of single indicator. Egghe [13], [16] says g-index is “the higher rank, such that the top g papers have at least g2 citations. It also means, that the top g + 1 have less than (g + 1)2 papers”. The g-index is always greater than or equal to h-index.

Data sets:

Iris is a set of total 150 data, each having four attributes, such as ‘septal’ length and breadth and ‘pedal’ length and breadth [14]. The dataset is divided into three class labels (e.g., iris setosa; iris versicolor; and iris verginica) each having equal data distributions, i.e., first 50 belongs to *iris setosa*, next 50 are *iris versicolor,* and the remaining 50 data belong to *iris verginica*).

2.2. Parameters to Measure the Clustering Performance

Data discrepancy factor (DDF): Data discrepancy is measured by noting the positional discrepancies among the data points during clustering. It is computed by adding the number of (i) ‘wrong’ data points grouped inside (WI), (ii) the ‘correct’ data points lying outside (WO) of any kth cluster and (iii) number of data points, which could not be clustered i.e. the outliers (OL) when matched with the representative data (Ck). Finally, it is expressed as a percentage of the total number of data points (N). Ideally, the DDF must be 0%, i.e. all the data points are clustered as it should be and there is nil outlier. Its significance is to evaluate the ‘under’ and ‘over’ fitting of the data. An example of DDF computation is given in:

$$DDF = \frac{1}{C_k}[(WI + WO + OL)] \times 100$$

Computational Time: The computational time, that is, an average user time values of original versus modified K-Means algorithm have been compared while carrying out clustering of the three datasets used in the study in a Core i3, 64-bit operating system with 4GB RAM and 2.2 GHz processor.

3. RESULTS AND DISCUSSION

K-means suffers from drawback on the number of clusters *k* as an input parameter. This is because of an inappropriate choice of *k* which might yield spurious results. Hence, it is always an important task to run diagnostic checks when using k-means clustering to resolve the number of clusters in the given dataset. Moreover, applying k-means value with values ranging from *k=2, 3, 4 or 5* depends on the number of objects in the dataset and to avoid expected clusters of similar size, so that the assignment of objects to the nearest cluster center or centroid will result in correct clusters.

Algorithm: K-Means

1. Initialization: choose k initial centroids arbitrarily (or randomly).
2. Assign each data point to the centroid that is closer to it.
3. Compute the distance between the centroids and objects using the Euclidean Distance equation
4. Update all the centroids and the new centroid of a cluster is the mean of all the points within that cluster.
5. Repeat points 2 and 3 until the new centroids are the same as the previous centroids.

Clustering by k-means algorithm will result in different runs each time the program is run. Though the difference is negligible, it should be noted that the cluster assignments change slightly for each time the algorithm is run. This is because k-means tries to find the locally optimal solution, but not a globally optimal one. Hence, the k-means algorithm was run more number of times to realize a consistently optimal solution.

But the problem still exists, that is, how to choose the best solution among two clustering solutions? Hence, a modified k-means algorithm was presented where a metric was used to calculate the sum of squares within-cluster to choose the best one. The sum of squares within the cluster represents the sum of all distances between each data point and the centroid of its cluster. The smaller the value, the more compact and good is the cluster. Therefore, for a given dataset, clusters with the smaller sum of squares within a cluster are regarded as generally better. The time required to perform both the algorithms are reported.

Modified K-Means Algorithm:

1. Initialization: choose k initial centroids arbitrarily (or randomly).
2. Assign each data point to the centroid that is closer to it.
3. Compute the distance between the centroids and objects using the Euclidean Distance equation
4. Update all the centroids and the new centroid of a cluster is the mean of all the points within that cluster.
5. Compute the sum of squares within-cluster to obtain a distance value between each data point and the centroid of its cluster.
6. Repeat k-means clustering n times (n=5) and return the clustering with the smallest sum of squares within-cluster.
7. Update the centroids.
8. Stop the process when new centroids are same as the previous centroids. Otherwise, go to step 3.

3.1. Clustering Performance on IRIS Dataset

Data discrepancy factor (DDF): An attempt was made to test the performance of modified K-means algorithm, while carrying out clustering on IRIS [10] and h-index and g indexes. Both IRIS as well as h and g indices datasets is ideally clustered into their respective groups. The results are given in Table 1 and 2.

Table 1. DDF calculation on IRIS dataset using k-means algorithm

# Cluster	Data Points	Target	Observed	# Wrong data points	OL	Proposed DDF (%)	Conventional DDF (%)
1	1-50	50	61	14	0		
2	51-100	50	49	0	1	{14+0+3+1/150}*100=12%	11+1+11+1/150}*100=16%
3	101-150	50	39	3	0		

Table 2. DDF calculation on IRIS dataset using k-means modified algorithm

# Cluster	Data Points	Target	Observed	# Wrong data points	OL	Proposed DDF (%)	Conventional DDF (%)
1	1-50	50	49	0	1		
2	51-100	50	62	14	0	{0+14+2+1/150}*100=11.33%	1+12+12+1/150}*100=17.33%
3	101-150	50	38	2	0		

One of the cluster quality measures is the DDF computation. It is calculated using an equation given above. DDF is the most important measure among all other measures to judge the performance of any clustering technique. Conventionally, good clustering is assessed by counting total number of data points within a cluster. If the number equals to the number of desired data points and the cluster is said to be perfect [15]. The goodness of the clustering techniques must not be judged based on only the data count inside a cluster, rather the goodness of a cluster must be tested by summing up the data points which are (i) present within a cluster where it should not be and vice versa and (ii) not clustered i.e. outliers (OL). From Table 3 and 4, it is evidenced that modified k-means algorithm presented in this paper performed well than normal algorithm.

3.2. Computational Time

Performance of the modified K-means algorithm was assessed by computing the time taken to complete the run using IRIS and h-g indices datasets. The results are summarized in Table 3 and 4.

Table 3. Computational time evaluation of regular and modified k-means algorithm

Dataset	K-means original (Run time in secs)	Modified K-means (Run time in secs)
IRIS	Run1: 5.82	Run1: 3.49
	Run2: 5.66	Run2: 3.30
	Run3: 5.64	Run3: 3.47
h-g indices	Run1: 15.21	Run1: 0.40
	Run2: 14.25	Run2: 0.37
	Run3: 15.22	Run3:0.37

Table 4. Comparison of time complexity of k-means original and modified algorithm while a varying number of clusters

Dataset	No. of clusters	K-means original (Run time in secs)	Modified K-means (Run time in secs)
IRIS	1	2.44	2.81
	2	3.52	3.06
	3	6.63	3.30
	4	7.70	3.72
	5	8.84	4.11
H-G indices	1	2.10	0.12
	2	6.16	0.16
	3	15.21	0.37
	4	16.20	0.39
	5	16.22	0.36

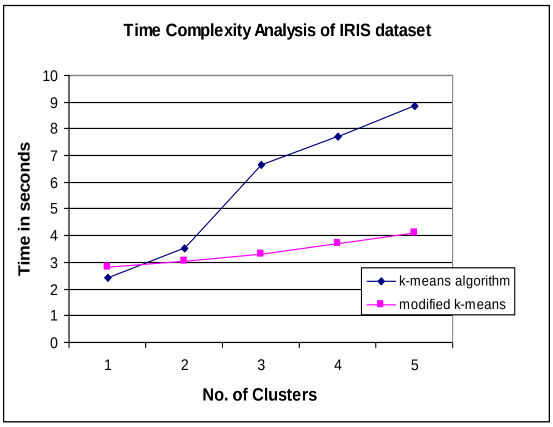


Figure 2. An Image showing time complexity analysis of IRIS dataset

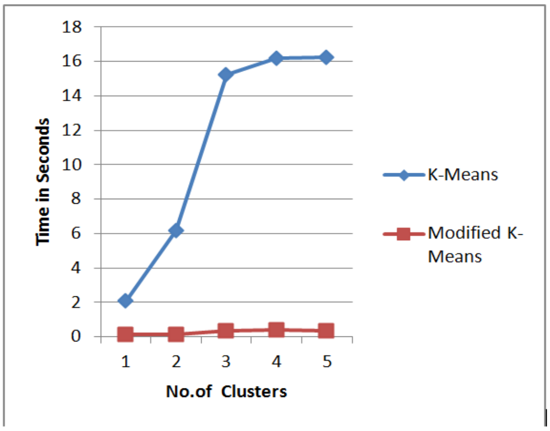


Figure 3. An Image showing time complexity analysis of h and g indices data

4. CONCLUSION

K-means is one of the easiest un-supervised learning algorithms that resolve the notorious clustering algorithm. The program classifies given dataset into predefined *k* clusters corresponding to the centroids. Considering the importance of h- and g-indices for each author as a parameter to assess the quality of published papers in various journals, a modified k-means algorithm was implemented to study the objects used. Analysis revealed that the modified k-means algorithm is much faster and outperforms the conventional algorithm both in terms of computational time and clustering performance, measured by data discrepancy factor.

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