



Inteligencia Artificial. Revista
Iberoamericana de Inteligencia Artificial

ISSN: 1137-3601

revista@aepia.org

Asociación Española para la Inteligencia
Artificial
España

Magdaleno, Damny; Miranda, Yadriel; Fuentes, Ivett E.; García, María M.
Comparative Study of Clustering Algorithms using OverallSimSUX Similarity Function for
XML Documents
Inteligencia Artificial. Revista Iberoamericana de Inteligencia Artificial, vol. 18, núm. 55,
2015, pp. 1-11
Asociación Española para la Inteligencia Artificial
Valencia, España

Available in: <http://www.redalyc.org/articulo.oa?id=92538718006>

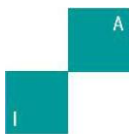
- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org

redalyc.org

Scientific Information System

Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal

Non-profit academic project, developed under the open access initiative



Comparative Study of Clustering Algorithms using OverallSimSUX Similarity Function for XML Documents

Damny Magdaleno, Yadriel Miranda, Ivett E. Fuentes, María M. García
Computer Science Department, Universidad Central “Marta Abreu” de Las Villas.
Carretera a Camajuaní, KM 5 ½, C.P. 54830, Santa Clara, Villa Clara, Cuba.
dmg@uclv.edu.cu; ymdorta@uniss.edu.cu; ivett@uclv.cu; mmgarcia@uclv.edu.cu

Abstract A huge amount of information is represented in XML format. Several tools have been developed to store, and query XML data. It becomes inevitable to develop high performance techniques for efficiently analysing extremely large collections of XML data. One of the methods that many researchers have focused on is clustering, which groups similar XML data, according to their content and structures. In previous work, there has been proposed the similarity function OverallSimSUX, that facilitates to capture the degree of similitude among the documents with a novel methodology for clustering XML documents using both structural and content features. Although this methodology shows good performance, endorsed by experiments with several corpus and statistical tests, on having had impliedly only one clustering algorithm, *K*-Star, we do not know the effect that it would suffer if we replaced this algorithm by other with dissimilar characteristics. Therefore to endorse completely the methodology, in this work we make a comparative study of the effects of applying the methodology for the OverallSimSUX similarity function calculation, using clustering algorithms of different classifications. Based on our analysis, we arrived to two important results: (1) The Fuzzy-SKWIC clustering algorithm works best both with methodology and without methodology, although there are not present significant differences respect to the *K*-Star and *G*-Star clustering algorithms, according to conclusions achieved by Nemenyi's post-hoc test.; (2) For each analysed algorithm when using the methodology, we obtain better results than when it is not taken into account.

Resumen Gran cantidad de información está almacenada en formato XML; varias herramientas se han desarrollado para almacenar y consultar datos en XML. Se hace inevitable crear técnicas para el análisis eficiente de grandes colecciones de estos documentos. Uno de los métodos en que los investigadores se han centrado es en el agrupamiento, basado en la estructura y contenido de los XML. En un trabajo anterior fue propuesta la función de similitud OverallSimSUX, que captura el grado de semejanza entre los documentos, utilizada con una nueva metodología para el agrupamiento de documentos XML utilizando estructura y contenido simultáneamente. Aunque esta metodología mostró buen desempeño, avalado por los experimentos con varios corpus y test estadísticos, al tener implícito un algoritmo de agrupamiento, *K*-Star; se desconoce el efecto que podría sufrir si se reemplaza este algoritmo por otro con diferentes características. Por tanto para avalar completamente la metodología, en este trabajo se realiza un estudio comparativo de los efectos de aplicar la metodología para el cálculo de la función de similitud OverallSimSUX, usando algoritmos de agrupamiento de diferentes clasificaciones. Basado en el análisis realizado, se arribaron a dos resultados importantes: (1) El algoritmo de agrupamiento Fuzzy-SKWIC obtuvo mejores resultados cuando es usado con la metodología al igual que cuando no es usado con esta, aunque no presenta diferencias significativas respecto a los algoritmos *K*-Star y *G*-Star, según el test de Nemenyi; (2) Para cada algoritmo analizado, cuando se utiliza la metodología, se obtienen mejores resultados que cuando no se utiliza la metodología.

Keywords: Comparative study, Clustering, XML.

Palabras clave: Estudio Comparativo, Agrupamiento, XML.

1 Introduction

XML [1] has been introduced by W3C in 1998 in order to eliminate the complexity of using SGML. A XML document is a structure hierarchical auto-descriptive of information in semi-structured format, since it incorporates structure and data in the same entity. This way, the structure of the documents can also be used to carry out recovery of relevant documents [2]. Therefore, it has become standard for information representation and exchange on the Web and the Internet [3]. Consequently, a huge amount of information is represented in XML and several tools have been developed to store and query XML data [4, 5].

It becomes inevitable to develop high performance techniques for efficiently managing and analysing extremely large collections of XML data [6]. One of the methods that many researchers have focused on is clustering, which groups similar XML data according to their content and structures. The clustering process of XML data plays a crucial role in many data application domains [6], such as information retrieval, data integration, document classification, Web mining, and query processing.

A clustering algorithm tries to find natural clusters of data based mainly on the similarity, so it is desirable that the objects that belong to the same cluster can be as similar as possible and the objects that belong to different clusters can be so more dissimilar [7].

The XML document clustering is a challenging task because it involves content as well as structure information [8]. There are some methods for XML documents that use the structural features [9, 10], the content features [11] or both structural and content features [12, 13] for clustering similar documents.

In previous work [14], a novel methodology for clustering XML documents using both structural and content features has been proposed. The similarity function OverallSimSUX, that facilitates to capture the degree of similitude among the documents, was proposed too in this work. Although this methodology shows good performance, endorsed by experiments with several corpus and statistical tests, on having had impliedly only one clustering algorithm, *K*-Star [15] we do not know the effect that it would suffer if we replaced this algorithm by other with dissimilar characteristics. Nevertheless to endorse completely the methodology, it is necessary to prove it with other clustering algorithms of diverse classifications.

In this work we make a comparative study of the effects of applying the methodology for the OverallSimSUX similarity function calculation, using clustering algorithms of different classifications. The paper is organized as follows: In section 2 there are described forms of clustering following different classifications; in section 3 we made a brief description about selected clustering algorithms to compare; in section 4 we talk about the methodology for computing OverallSimSUX similarity function; in section 5 the experimental results are analysed and finally, in section 6 the conclusions are presented.

2 Cluster Algorithms

Clustering methods are usually classified with respect to their underlying algorithmic approaches. A great variety of clustering algorithms for making groups' analysis has been proposed. These algorithms can be classified of diverse forms: input type, criteria to define the similarity between the objects, concepts on which the analysis is based, forms of representation of the information, and others. In general, in this classification two types differ: those that form divisions and the hierarchic ones. Figure 1 shows clustering algorithms' taxonomy bearing in mind this classification.

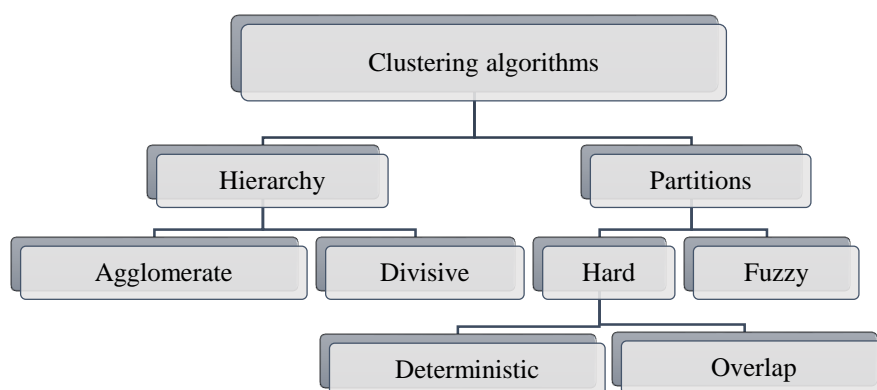


Figure 1. Clustering algorithms taxonomy

Hierarchical algorithms find successive clusters using previously established ones, whereas partition algorithms determine all clusters at once. Hierarchical algorithms can be agglomerative or divisive; agglomerative algorithms begin with each element as a separate cluster and merge the obtained clusters into successively larger clusters. Divisive algorithms begin with the whole set and proceed to divide it into successively smaller clusters. Iterative algorithms start with some initial clusters (their number either being unknown in advance or given a priori) and intend to successively improve the existing cluster set by changing their “representatives” (“centers of gravity” or “centroids”), like in *K*-Means [16] or by iterative node-exchanging (like in [17]).

The goal of the methods that make partitions is to find the best data partition in k clusters ($k \in \mathbb{N}, k > 0$). These methods use a similarity function. The majority of the algorithms that follow this approach are essentially based on prototypes [7].

Algorithms that belong to this taxonomy are *k*-means [18], widely used. *PAM* (*Partitioning Around Medoids*) is other algorithm [19], its objective is to find a representative object for each cluster. *K*-Mode and *K*-prototypes [20] are based in *K*-means. Other technique is SKWIC, “Simultaneous Keyword Identification and Clustering of text documents”, conceptually and computationally simple, and it offers several advantages [21].

Other classification, not mutually exclusive to the already presented one, considers the way of manipulating the uncertainty in cluster overlapped terms: hard and fuzzy clustering [22]. The fuzzy clustering is subdivided into probabilistic and possibilistic [7]. Among these techniques [23] proposed a change to the classic fuzzy *c*-means, which is a new strategy for selecting the initial centers of cluster.

Being the XML documents semi-structured, there are three forms of computing the distances or similarities of these: (1) only considering the content of the documents; (2) considering only the structure; and (3) the clustering that considers these two dimensions of the documents XML (structure and content). Figure 2 shows a summary of some XML cluster algorithms.

Only Content	Kurgan, L. “ <i>Semantic mapping of xml tags using inductive machine learning.</i> ” [7]	Use some variant of VSM.
	Shen, Y. “ <i>Clustering schemaless xml document.</i> ” [8]	
Only Structure	Dalamagas, T. “ <i>A Methodology for Clustering XML Documents by Structure.</i> ” [2]	Use a XML tree representation to calculate some variant of tree-edit distance.
	Flesca, S. “ <i>Fast detection of XML structural similarities.</i> ” [5]	
	Lesniewska, A. “ <i>Clustering XML documents by structure.</i> ” [10]	
	Chawathe, S.S. “ <i>Comparing Hierarchical Data in External Memory.</i> ” [11]	Considering XML structure based on the use of Edit Graph.
	Costa, G. “ <i>Hierarchical clustering of XML documents focused on structural components.</i> ” [13]	A new hierarchical approach is proposed.
	Aïtelhadj, A. “ <i>Using structural similarity for clustering XML documents.</i> ” [12]	Follow the two-step approach to cluster XML document.
Structure and Content	Kutty, S. “ <i>Combining the structure and content of XML documents for clustering using frequent subtrees.</i> ” [16]	There was used the Closed Frequent Sub-Trees.
	Yang, W. “ <i>A semi-structured document model for text mining.</i> ” [17]	Analyzed variant of XML document compare based in VSM.
	Tekli, J.M. “ <i>A Novel XML Document Structure Comparison Framework based-on Subtree Commonalities and Label Semantics.</i> ” [18]	Framework to deal with both structural and semantic similarities in XML documents. Use tree edit-distance.
	Pinto, D. “ <i>BUAP: Performance of K-Star at the INEX’09 Clustering Task.</i> ” [19]	Using the iterative clustering algorithm K-Star in a recursive clustering process.

Figure 2. Summary of XML cluster algorithms¹

¹ 14. Magdaleno, D., I.E. Fuentes, and M.M. García, *Clustering XML Documents using Structure and Content Based in a Proposal Similarity Function (OverallSimSUX)*. Computación y Sistemas, 2015. **19**(1). (Reproduced with permission of the author)

3 Selected Algorithms

To make the comparative study we select four cluster algorithms with different features, (1) *K*-Star, agglomerative; (2) Generalized Star (G-Star), based in graphs; (3) Simultaneous Keyword Identification and Clustering of text documents (SKWIC), hard and deterministic partitions; (4) Fuzzy SKWIC, fuzzy partitions. The next sections show a brief background about these algorithms.

3.1 *K*-Star

K-Star is a hierarchical agglomerative clustering method which automatically reveals the number of clusters, unknown in advance [13]. As most of the clustering methods, it requires a similarity matrix of the documents to be clustered (corpus). *K*-Star clustering approach can be explained as below.

1. It looks for the maximum value in the similarity matrix $\varphi(d_i, d_j)$, and constructs a cluster (C_i) made up of the two documents this similarity value refers to. It marks these documents (d_i and d_j) as assigned.
2. For each unassigned document (dk)
 - If $\varphi(d_i, d_j) > \tau$, where τ is a given threshold, then add dk to cluster C_i and mark dk as assigned.
3. Return to Step 1

In [13] is presented the entire pseudo source of this algorithm.

3.2 G-Star

The Generalized Star (G-Star) algorithm was proposed in [24] following the Aslam approach [23]. *G*-Star defines a set group for each graph vertex, professed *WeakSats* and *PotSats*. The basic steps of this algorithm are:

1. To build the graph $G\beta$ for collection representation.
2. To build de list L with all graph vertex, with this list realize an iterative process for chose the vertex v with *PotSats* biggest degree in L .
 - Add this vertex to X .
 - Update adjacent vertex.
 - Delete v from L
3. Repeat step 2 until L is empty.
4. Sort vertex in X , taking into account *PotSat* degree.

In [25] is presented the entire pseudo source of this algorithm and an extensive analysis.

3.3 SKWIC

The SKWIC algorithm is an extension of SCAD algorithm to simultaneous text document clustering and dynamic category dependent keyword set weighting. SKWIC is both conceptually and computationally simple, and offers advantages compared to existing document clustering techniques [26].

SKWIC clustering approach can be explained as below.

1. To fix the number of clusters C and initialize the centers by randomly selecting C documents.
2. To initialize the partitions.
3. To update the relevance weights.
4. To calculate the distance from documents to the cluster's center and assign each document to the cluster.
5. To update the cluster's center.
6. To return Step 3 until the center is stabilized.

This algorithm needs to know the cluster number to be created. In [26] is presented the entire pseudo source of this algorithm and an extensive analysis.

3.4 Fuzzy SKWIC

Fuzzy-SKWIC (F-SKWIC) was designed to search for the optimal cluster center, the optimal soft partitioning memberships and the optimal set of feature weights, simultaneously [26].

- 1 To fix the number of clusters C ; initialize the centers by randomly selecting C documents and initialize document membership to each cluster.

- 2 To calculate the term relevance; the distance of the document to each cluster's center.
- 3 To update document membership to each cluster;
- 4 To recalculate cluster's center and update the center.
- 5 To return Step 2 until the center is stabilized.

This algorithm needs to know the cluster number to be created. In [26] is presented the entire pseudo source of this algorithm and an extensive analysis.

4 OverallSimSUX Based Methodology

The methodology for clustering XML documents proposed in [14] computes a final similarity matrix based in the OverallSimSUX similarity function. For the matrix calculations is necessary: (1) to make two different representation to corpus, (2) a matrix of similarity is calculated, which compares two documents using the Cosine measure [27]; this is shown in the equation 1, (3) finally an intermediate clustering is realized. The general procedure of this methodology is shown in figure 3.

$$S_{Cosine}(d_i, d_j) = \frac{\sum_{r=1}^s (d_{ir} \times d_{jr})}{\sqrt{\sum_{r=1}^s d_{ir}^2 \times \sum_{r=1}^s d_{jr}^2}} \quad (1)$$

```

Input: Corpus D of XML documents
Output: Set of Cluster, cluster quality,
the more representative document by
cluster.
Begin
1. Pre-process /* lexical analysis, stop
word elimination, stemming... */
2. Build all the k-collection(corpus D)
3. For each DSUk
   - Rep-I ← Make Representation-I(DSUk)
   according to TF-IDF
   - Sim_matrix ← Calculate similarity
matrix to Rep-I using
Cosine measure
   - Clusters ← Apply K-Star clustering
method to Sim_matrix
end_for
4. Rep-II ← Make Representation-II to
entire corpus D using equation
(5) for calculate the frequency
5. Sim_matrixII ← Calculate similarity
matrix to Rep-II using
Cosine measure
6. O_Sim_Matrix ← Calculate similarity
matrix using OverallSimSUX
measure taking into
account all the clustering
of all DSUk and
Sim_matrixII
7. Make final clustering applying K-Star
clustering method to O_Sim_matrix
end

```

Figure 3. General procedure of XML clustering methodology with OverallSimSUX similarity²

² 14. Ibid. (Reproduced with permission of the author)

5 Experimental Setup

To make the comparative study three experiments have been designed, applied to three data sets, with the purpose of carrying out a statistical analysis that allows showing the result of both, the selected algorithms without using the methodology and the selected algorithms using the methodology. All approaches were implemented in a system for clustering scientific papers in XML format (LucXML).

To evaluate the results we implemented the external measure *Overall F-measure* [28] for showing the quality of the groups obtained in each clustering.

Overall F-measure measure is based in *Precision (Pr)* and *Recall (Re)* measure [29]. The *Pr* and *Re* are calculate for a cluster *g* and a class *c* as follows.

$$Pr(c, g) = \frac{n_{cg}}{n_g} \quad (2)$$

$$Re(c, g) = \frac{n_{cg}}{n_c} \quad (3)$$

Where n_{cg} is the objects' number of the class *c* in the cluster *g*, n_g is objects' number of the cluster *g* and n_c is the objects' number of the class *c*. With this value the *F-measure* is calculated and the harmonic means of *Pr* and *Re* are obtained, as shown in expression 4.

$$FM(c, g) = \frac{1}{\alpha \left(\frac{1}{Pr(c, g)} \right) (1 - \alpha) \left(\frac{1}{Re(c, g)} \right)} \quad (4)$$

If $\alpha = 1$ then $FM(c, g)$ coincide with *Pr* value, else if $\alpha = 0$ then $FM(c, g)$ coincide with *Re* value. So, $\alpha = 0.5$ means equal weight for *Pr* and *Re*. Finally Overall F-measure (OFM) is calculated using expression 5.

$$OFM = \sum_{i=1}^k \frac{n_c}{n} \max\{FM(c, g)\} \quad (5)$$

5.1 Case Study

- *Case study 1*: Documents recovered from the site of ICTs of the Center of Studies on Informatics of the Universidad Central "Marta Abreu" de las Villas (UCLV). <http://ict.cei.uclv.edu.cu>.
- *Case study 2*: Summary of documents of the *IDE-Alliance* repository. Provided by the University of Granada, Spain.
- *Case study 3*: Summary of documents of the collection of the Wikipedia, published by the "Initiative for the Evaluation of XML Retrieval", INEX'09, to evaluate clustering. <http://www.inex.otago.ac.nz>

We conform 16 XML documents corpora. Corpus 1 to 7 with documents from case study 1, the average size of each corpus is 1'000 documents; corpus 8 to 11 with documents from case study 2, the average size of each corpus is 5'000 documents; the rest of the corpora are the case study 3, the average size of each corpus corresponding to last case study 3 is 10'000 documents. Each corpus are independent. Figure 4 shows a fragment of XML document corresponding to corpus 9 of case study 2. We not take into account the *class* label in the cluster process, this is used only for the results' evaluation.

5.2 Experiments' Results and Analysis

The first experiment consisted on verifying how it behaves globally, on the three data sets described previously, the four algorithm selected without using the methodology for *OverallSimSUX* calculation. Table 1 shows this result.

In the second experiment it is verified how they behave globally, on the 16 corpus, the four algorithms selected using the methodology for *OverallSimSUX* calculation. The experiments' results are shown in Table 2.

The last experiment consists in comparing pairwise formed by the result of the same algorithm, using the methodology and without using the methodology. Figure 5 shows this result; one chart for each algorithm.

Both in the first one and in the second experiment, the results were similar. The best results were achieved by the F-SKWIC algorithm that obtained better or equal results than other algorithms in the 56.25% of the cases in both experiments. The second better algorithm in both experiments was *K-Star* algorithm, with better or equal result than other algorithms in the 31.25% of the cases. Following this analysis idea, the results achieved in both experiments coincided with 12 of 16 corpus.

```
<?xml version="1.0" encoding="utf-8"?>
<paper>
  <class>0</class>
  <front>
    <title>Maximum Weight Matching via Max-Product Belief
    Propagation </title>
    <conference/>
    <authors>
      <author>
        <fname>Bayati</fname>
        <surname>Mohsen<surname/>
        ...
      </author>
      ...
    </authors>
    <keywords>
      <keyword>belief propagation </keyword/>
      ...
    </keywords>
    <abstract>
      <para>The max-product "belief propagation" algorithm is an
      iterative, local, message passing algorithm finding the ...
      </para>
    </abstract>
  </front>
  <body>
    <section>
      <title>Introduction</title>
      <para>I. INTRODUCTION Graphical models (GM) are a powerful
      method representing and manipulating joint probability
      distributions. ...
    </section>
    ...
  </body>
</paper>
```

Figure 4. Fragment of XML document used in the experiment.

Table 1. Values of the Overall F-Measure for the four algorithms, when the methodology is not used

Corpus	K-Star	SKWIC	G-Star	F-SKWIC
1	0.6943	0.5300	0.6400	0.7214
2	0.6000	0.4955	0.6650	0.6138
3	0.6825	0.4634	0.6050	0.6670
4	0.4717	0.3524	0.4418	0.4785
5	0.6753	0.2858	0.4604	0.8307
6	0.4745	0.2248	0.3325	0.4739
7	0.5813	0.3325	0.4850	0.4624
8	0.8990	0.5530	0.7952	0.7453
9	0.6249	0.3307	0.5146	0.8925
10	0.6461	0.4892	0.7650	0.6787
11	0.7715	0.5028	0.7922	0.8819
12	0.9239	0.4393	0.7145	0.9239
13	0.9582	0.5810	0.6289	0.9601
14	0.9047	0.3453	0.5091	0.9839
15	0.8830	0.3207	0.5914	0.9139
16	0.6682	0.8883	0.9364	0.7388

Table 2. Values of the Overall F-Measure for the four algorithms, when the methodology is used

Corpus	K-Star	SKWIC	G-Star	F-SKWIC
1	0.8204	0.6221	0.7463	0.8524
2	0.7418	0.4746	0.5199	0.7589
3	0.8564	0.4825	0.5384	0.8369
4	0.7100	0.4337	0.4599	0.7202
5	0.6371	0.2792	0.4663	0.7837
6	0.6861	0.2904	0.3880	0.6852
7	0.7322	0.3181	0.4716	0.5824
8	0.8862	0.5821	0.8981	0.8815
9	0.8520	0.4003	0.5602	0.8862
10	0.8147	0.4884	0.8772	0.8558
11	0.8952	0.5731	0.8874	0.8741
12	0.9471	0.4464	0.7198	0.9471
13	0.9526	0.6148	0.7112	0.9545
14	0.8885	0.3443	0.5154	0.9663
15	0.7998	0.3105	0.6150	0.8278
16	0.7485	0.9412	0.9412	0.8276

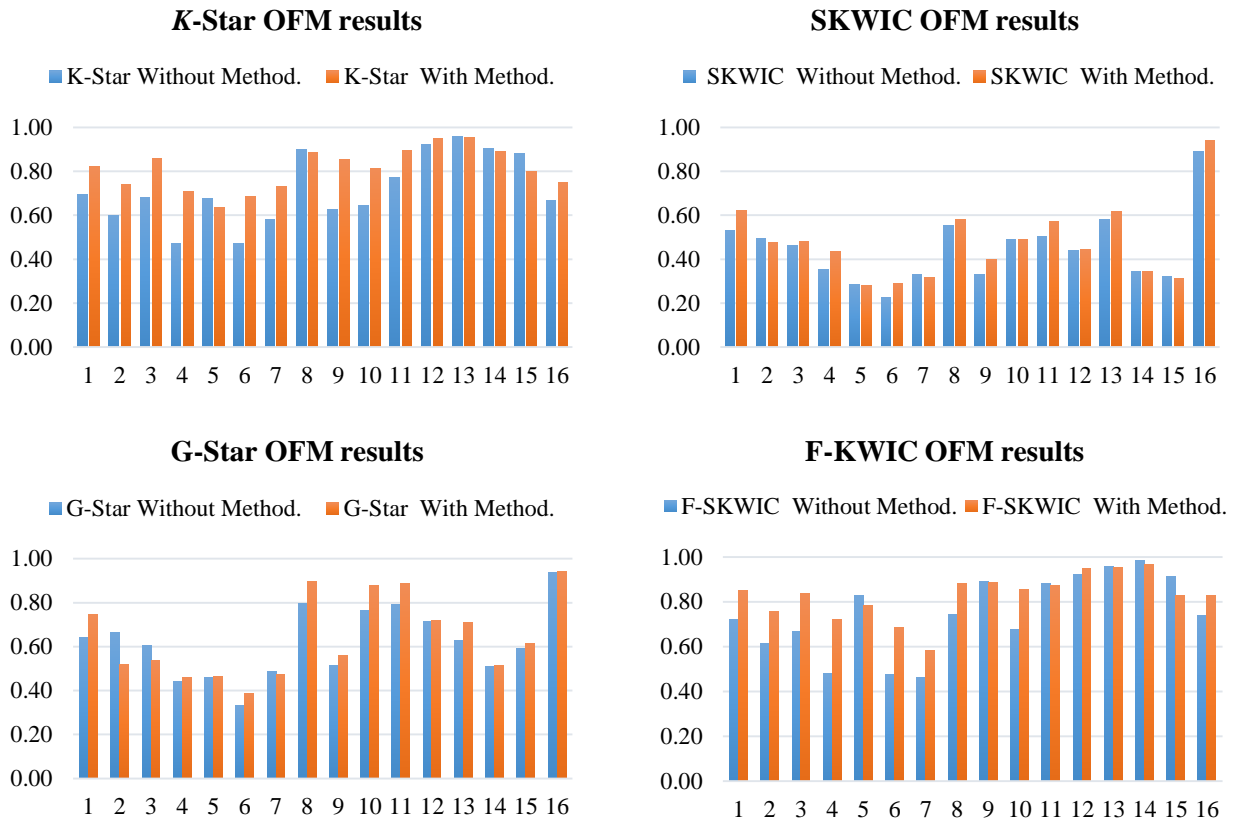


Figure 5. Comparison pairwise formed by the result of the same algorithm, using the methodology and without using the methodology

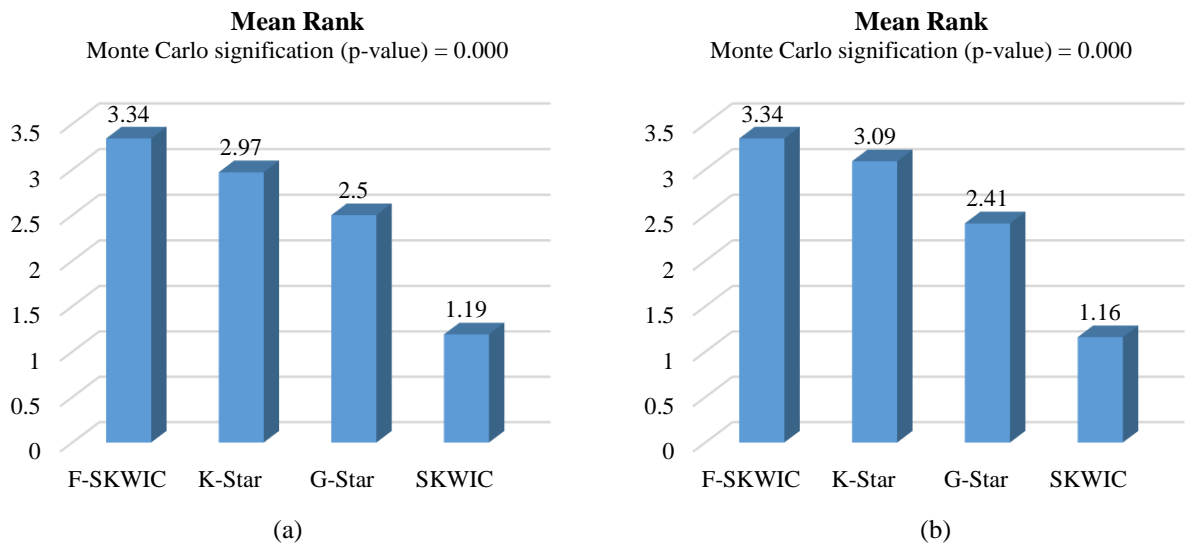


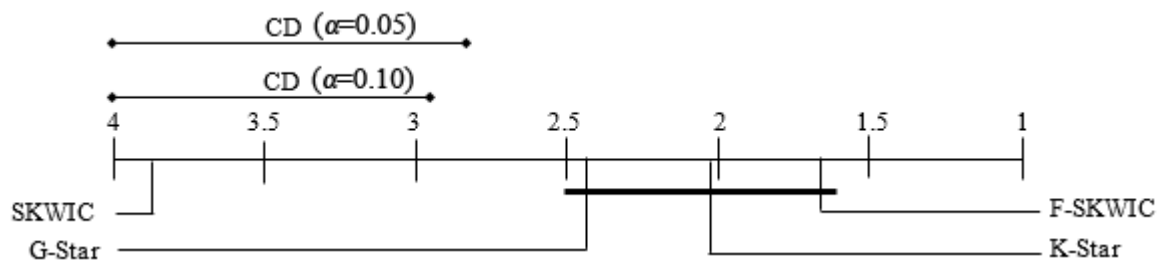
Figure 6. Mean rank achieved by the Friedman's test for (a) algorithms without using the methodology, (b) algorithms with using the methodology

In order to prove this, for both experiments we computed the Friedman's test (Friedman's two-way analysis of variances by ranks) [30]. This test is a multiple comparison procedure capable to detect significant differences between the behaviours of two or more algorithms; i.e., it can be used for discovering whether at least two of the

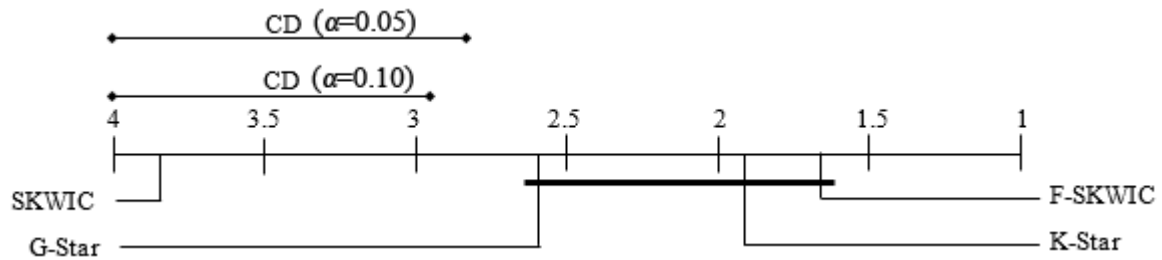
samples represent populations with different median values or not, in a set of n samples ($n \geq 2$). Figure 6 shown the mean rank and the p -value associated to this test for each algorithm without methodology and with methodology respectively.

Using a significance level of 0.05, corresponding to the 95% confidence interval, the Friedman's test ($p\text{-value} < 0.05$) suggests rejecting the null hypothesis, thus, there exist highly significant differences between at least two algorithms. Also, it can be observed that F-SKWIC and K-Star are best ranked; however, this information cannot be used to conclude that our proposals are involved in these differences; that is why we also applied the Nemenyi post-hoc test [31] after the Friedman test.

With Nemenyi, the performance of two classifiers is significantly different if the corresponding average ranks differ by at least the critical difference (CD) where critical values q_α are based on the Studentized range statistic divided by $\sqrt{2}$ [32]. For 16 datasets and four algorithms, using $\alpha = 0.05$ the CD value is 1.17, when $\alpha = 0.10$ CD value is 1.04. The results of Nemenyi post-hoc tests is visually represented in the Figure 7, using both $\alpha = 0.05$ and $\alpha = 0.10$. The top lines in the diagrams corresponds to the CD values, in the axis we plot the average ranks of methods. The axis is turned so that the lowest (best) ranks are to the right since we perceive the methods on the right side as better [32].



(a) Algorithms without using the methodology, results of the analysis of data from Table 1.



(b) Algorithms with using the methodology, results of the analysis of data from Table 2.

Figure 7. Visualization of Nemenyi post-hoc tests using both $\alpha = 0.05$ and $\alpha = 0.10$. Groups of algorithms that are not significantly different are connected with bold line.

Using Keel software [33], we compute the p -value achieved on Nemenyi post-hoc comparisons for $\alpha = 0.05$, $\alpha = 0.10$. Table 3 and Table 4 shows these results.

Table 3. Results achieved on Nemenyi post hoc comparisons, when the methodology is not used

Pairwise comparisons	(p -value) ^{a,b}
F-SKWIC vs. SKWIC	0.000001
F-SKWIC vs. K-Star	0.411314
F-SKWIC vs. G-Star	0.086964
K-Star vs. SKWIC	0.000054
K-Star vs. G-Star	0.373439
G-Star vs. SKWIC	0.001636

Table 4. Results achieved on Nemenyi post hoc comparisons, when the methodology is used

Pairwise comparisons	(p -value) ^{a,b}
F-SKWIC vs. SKWIC	0.000002
F-SKWIC vs. K-Star	0.583882
F-SKWIC vs. G-Star	0.03998
K-Star vs. SKWIC	0.000022
K-Star vs. G-Star	0.132006
G-Star vs. SKWIC	0.00617

^aFor $\alpha = 0.05$, Nemenyi's procedure rejects those hypotheses that have a p -value ≤ 0.008333

^bFor $\alpha = 0.10$, Nemenyi's procedure rejects those hypotheses that have a p -value ≤ 0.016667

These results statistically confirm that the better results in both experiments were achieved by F-SKWIC, although there are not present significant differences respect to the *K*-Star and *G*-Star clustering algorithms, for the analysed case studies.

The non-parametric test of Wilcoxon was applied for the results of experiment 3, to check if there are significant differences between the pairwise results of the algorithms (when the methodology is used and when it is not) for checking if the studied algorithms achieved better results using the *OverallSimSUX* methodology. Table 5 shows the results of this test.

Table 5. Wilcoxon's test statistics of pairwise comparison, when the methodology is used (i.e. *mG-Star*) and when is not (i.e. *G-Star*)

Pairwise comparisons	Sum of Ranks	(<i>p</i> -value) ^a
mF-SKWIC - FSKWIC	Neg. 23	0.009
	Pos. 113	
mK-Star - K-Star	Neg. 18	0.004
	Pos. 118	
mGStar - G-Star	Neg. 30	0.024
	Pos. 106	
mSKWIC - SKWIC	Neg. 25	0.011
	Pos. 111	

^aMonte Carlo signification

The Wilcoxon's test suggests to reject the null hypothesis ($p\text{-value} < 0.05$) for all pairwise comparisons. These results statistically confirm that the four studied algorithms achieved better results using the methodology for *OverallSimSUX* similarity calculation than without using this methodology, for the analysed case studies.

6 Conclusions

In this paper we have analysed the impact upon the methodology for clustering XML documents using *OverallSimSUX* similarity function of clustering algorithms of different classifications. From the above results, we can infer that for the analysed case study, Fuzzy-SKWIC clustering algorithm works best both, with methodology and without methodology, although there are not present significant differences respect to the *K*-Star and *G*-Star clustering algorithms, according to conclusions achieved by Nemenyi's post-hoc test. For each analysed algorithm and the cases study selected, when using the methodology we obtain better results than when it is not taken into account.

In the future, we hope to analyse impacts of other different clustering algorithms and to incorporate the study of effects of other popular similarity measures for documents clustering.

References

1. Brau, B., et al., *Extensible Markup Language(XML) 1.0.*, in *W3C Recommendation*. 1998.
2. Guerrini, G., M. Mesiti, and I. Sanz, *An Overview of Similarity Measures for Clustering XML Documents*. 2006.
3. Wilde, E. and R.J. Glushko, *XML fever*. Comm. ACM, 2008. **51**(7): p. 40-46. doi: [10.1145/1364782.1364795](https://doi.org/10.1145/1364782.1364795)
4. Wang, G., et al., *RPE query processing and optimization techniques for XML databases*. J. Comput. Sci. Technol., 2004. **19**(2): p. 224-237.
5. Bertino, E. and E. Ferrari, *XML and data integration*. IEEE Internet Comput., 2001. **5**(6): p. 75-76. doi: [10.1109/4236.968835](https://doi.org/10.1109/4236.968835)
6. Algergawy, A., et al., *XML Data Clustering: An Overview*, in *ACM Computing Surveys*. 2011. doi: [10.1145/1978802.1978804](https://doi.org/10.1145/1978802.1978804)
7. Kruse, R., C. Döring, and M.-J. Lessor, *Fundamentals of Fuzzy Clustering*, in *Advances in Fuzzy Clustering and its Applications*, J.V.d. Oliveira and W. Pedrycz, Editors. 2007, John Wiley and Sons: Est Sussex, England. p. 3-27.
8. Ji, T., X. Bao, and D. Yang, *FXProj – A Fuzzy XML Documents Projected Clustering Based on Structure and Content*. LNAI 7120, 2011: p. 406-419.

9. Yousuke, W., K. Hidetaka, and Y. Haruo, *Similarity search for office XML documents based on style and structure data*. International Journal of Web Information Systems., 2013. **9**(2): p. 100-117. doi: [10.1108/IJWIS-03-20-13-0005](https://doi.org/10.1108/IJWIS-03-20-13-0005)
10. Costa, G., et al. *Hierarchical clustering of XML documents focused on structural components*. in *Data & Knowledge Engineering*. 2013. doi: [10.1016/j.datak.2012.12.002](https://doi.org/10.1016/j.datak.2012.12.002)
11. Kurgan, L., W. Swiercz, and K.J. Cios. *Semantic mapping of xml tags using inductive machine learning*. in *11th International Conference on Information and Knowledge Management*. 2002. Virginia, USA.
12. Tekli, J.M. and R. Chbeir, *A Novel XML Document Structure Comparison Framework based-on Subtree Commonalities and Label Semantics*. Elsevier, 2011. **11**(2011). doi: [10.1016/j.websem.2011.10.002](https://doi.org/10.1016/j.websem.2011.10.002)
13. Pinto, D., M. Tovar, and D. Vilariño. *BUAP: Performance of K-Star at the INEX'09 Clustering Task*. in *INEX 2009 Workshop Pre-proceedings*. 2009. Woodlands of Marburg, Ipswich, Queensland, Australia. doi: [10.1007/978-3-642-14556-8_43](https://doi.org/10.1007/978-3-642-14556-8_43)
14. Magdaleno, D., I.E. Fuentes, and M.M. García, *Clustering XML Documents using Structure and Content Based in a Proposal Similarity Function (OverallSimSUX)*. Computación y Sistemas, 2015. **19**(1).
15. Shin, K. and S.Y. Han, *Fast clustering algorithm for information organization*., in *In:Proc. of the CICLing Conference*. 2003, Lecture Notes in Computer Science.Springer-Verlag (2003). p. 619–622. doi: [10.1007/3-540-36456-0_69](https://doi.org/10.1007/3-540-36456-0_69)
16. MacQueen, J.B., *Some methods for classification and analysis of multivariate observations*, in *Proc. 5th Berkeley Symposium on Mathematical Statistics and Probability*. 1967: Berkeley, University of California. p. 281-297.
17. Kernighan, B.W., Lin, S., *An efficient heuristic procedure for partitioning graphs*. Bell Systems Technical Journal, 1970. **49**(2): p. 291-308. doi: [10.1002/j.1538-7305.1970.tb01770.x](https://doi.org/10.1002/j.1538-7305.1970.tb01770.x)
18. Xiong, H., J. Wu, and J. Chen. *K-means clustering versus validation measures: a data distribution perspective*. in *Proceedings of the 12th ACM SIGKDD international conference on Knowledge discovery and data mining (KDD 2006)*. 2006. Philadelphia, PA, USA: ACM Press. doi: [10.1109/TSMCB.2008.2004559](https://doi.org/10.1109/TSMCB.2008.2004559)
19. Kaufman, L. and P.J. Rousseeuw, *Finding groups in data: an introduction to cluster analysis*. Wiley Series in probability and mathematical statistics. 1990: John Wiley and Sons.
20. Olmos, Y.P. and J.M.M. Martinez, *Estudio de metodos de agrupamiento en el contexto del resumen de corpus textuales*, in *Ciencia de la Computacion*. 2005, Universidad Central "Marta Abreu" de Las Villas. p. 104.
21. Berry, M.W., *Survey of Text mining: Clustering, Classification, and Retrieval*. 2004, New York, USA: Springer Verlag. doi: [10.1007/978-1-4757-4305-0](https://doi.org/10.1007/978-1-4757-4305-0)
22. Höppner, F., et al., *Fuzzy cluster analysis: methods for classification, data analysis and image recognition*. 1999, West Sussex, England: John Wiley & Sons Ltd.
23. ASLAM, J., E. PELEKHOV, and R. D., *The star clustering algorithm for static and dynamic information organization*. Journal of Graph Algorithms and Applications,, 2004. **8**.
24. Pérez, A. and J.E. Medina. *A clustering algorithm based on generalized stars*. in *Proceedings of the 5th International Conference on Machine Learning and Data Mining in Pattern Recognition (MLDM 2007)*. 2007. Leipzig, Germany: Springer Verlag. doi: [10.1007/978-3-540-73499-4_19](https://doi.org/10.1007/978-3-540-73499-4_19)
25. Pérez, A., et al., *Algoritmos de agrupamiento para colecciones de documentos*, in *Serie Gris*. 2008.
26. Frigui, H. and O. Nasraoui, *Simultaneous clustering and dynamic keyword weighting for text documents*. 2001. doi: [10.1007/978-1-4757-4305-0_3](https://doi.org/10.1007/978-1-4757-4305-0_3)
27. Korfhage, R.R., *Information Storage and Retrieval*. Wiley, 1997.
28. Steinbach, M., G. Karypis, and V. Kumar. *A comparison of document clustering techniques*. in *Proceedings of 6th ACM SIGKDD World Text Mining Conference*. 2000. Boston: ACM Press.
29. Frakes, W.B. and R. Baeza-Yates, *Information Retrieval. Data Structure & Algorithms*. 1992, New York: Prentice Hall.
30. Sheskin, D.J., *Handbook of Parametric and Nonparametric statistical procedures*, ed. C. Hall/CRC. 2004, New York. 1184. doi: [10.1198/tech.2001.s629](https://doi.org/10.1198/tech.2001.s629)
31. Nemenyi, P.B., *Distribution-free multiple comparisons*. 1963, Princeton University.
32. Demsar, J., *Statistical Comparisons of Classifiers over Multiple Data Sets*. Journal of Machine Learning Research, 2006. **7**(2006): p. 1-30. doi: [10.1.1.141.3142](https://doi.org/10.1.1.141.3142)
33. SCI2S, *Keel Tool 2.0*. 2010: Universidad de Granada.