Search Result Clustering Adrian Apap, Alan Falzon, Juan Buhagiar and Yurgen Schembri

Faculty of ICT, University of Malta, Msida adrian.apap.14@um.edu.mt, alan.falzon.14@um.edu.mt, juan.buhagiar.14@um.edu.mt, yurgen.schembri.14@um.edu.mt

Abstract

User queries in search engines may be ambiguous and have different senses. As a result, the search engine results may pertain to these different senses and may not all be relevant to the user.

An internet browser extension which clusters web search engine results was developed. Four different clustering algorithms, namely K-Means, No-K-Means, Clustering with a Self-Organising Map and Spectral Clustering were investigated. After evaluating the fitness of all, using the SemEval 2013 Task 11 gold standard collection, the former three were then applied to the add-on.

After the clustering occurs, each cluster is labelled, using a simple technique, with an extended search query which fits most results in the cluster. This is done in order to help the user articulate his query better, if necessary.

When testing the extension using Google search results, the three algorithms implemented in the extension returned satisfactory clusters, with No-K-Means giving better results. This was also reflected when all the algorithms were evaluated using the SemEval 2013 Task 11 gold standard.

1. Introduction

Search results clustering is the process of categorizing search results in meaningful groups. The clusters, containing a label which describes them, help the user to identify and search through the category which is in accordance with their interest, thus information is retrieved quicker by the user. This is particularly useful when a search query has multiple meanings. For example, the search query "jaguar" may refer to cats, cars, or maybe even something else. The search engine may return scattered results corresponding to these different meanings. Users are typically interested in only one meaning, and may not be able to express their needs well enough. By clustering the results and labelling them, the users should be able to identify the results relevant to their requirements more easily and may also further their search by altering their query to what is suggested by the cluster label.

The aim of this task is to develop a Google Chrome extension which performs search result clustering on results retrieved from the Google search engine, using different algorithms and to compare their results in order to determine the algorithm fittest for the application.

The browser extension was developed for Google Chrome as it is the most used internet browser [1] and operates on Google search results. When the user accesses the Google results page, the extension button becomes enabled and when clicked, the user chooses the preferred algorithm to cluster the

results, through a drop-down menu. The clustered results are then presented to the user on the same page.

The unsupervised search result clustering algorithms operate on weighted term vectors. These are extracted from search result snippets, using the bag-of-words model, with the term frequency as the weight.

The three clustering algorithms, K-Means, No-K-Means and Clustering with a Self-Organising Map, were tested on Google search results, taking into consideration the clustering quality and the time of execution. These algorithms, along with another clustering algorithm, Spectral Clustering, were evaluated using the Gold Standard Dataset provided in SemEval 2013 Task 11 [2], where the accuracy is based on the obtained values of F1, Rand Index, Adjusted Rand Index and Jaccard Index.

A background of the algorithms and their implementations are discussed in sections 2 and 3, and The Google Chrome extension is discussed in section 4. In section 5 and 6, we discuss testing and evaluation, respectively, while we summarize our work distribution in section 8. In section 9, we conclude our task documentation.

2. Background

In this section, an overview or unsupervised clustering, cluster analysis and the algorithms discussed in this document is given.

2.1 Unsupervised Clustering

Unsupervised clustering algorithms are used to draw inferences from datasets which consist of data but are not labelled. In this project we will use cluster analysis, which is used to find patterns or groups from the data. The clusters are modelled using similarity metrics such as Euclidean and Cosine Distance. Since all the examples are unlabelled there is no evaluation function to identify potential solutions, hence one cannot utilise training. The algorithms described hereafter were used to try to find the best solutions for unlabelled data.

2.2 Cluster Validity Indices

In this project, two different indices are used as cluster validity indices; Dunn's Index and PBM Index, discussed below. These are both used to measure how correct the clusters seem to be without having any information about the contents of the clusters.

2.2.1 Dunn's Index

The aim of this metric is to identify sets of clusters that are compact, with small variance between data in clusters and separated well, meaning that clusters are as far away as possible. The Dunn's Index is used in the testing phase to identify the best number of clusters. The higher the Dunn's Index the better the clustering. [3]

The Dunn's Index is calculated using Eq. 5 below.

$$d_{kk'} = min_{i \in I_k} \int_{j \in I_{k'}} \left\| M_i^{\{k\}} - M_j^{\{k'\}} \right\|$$
 Eq. 1

$$d_{min} = min_{k \neq k'} d_{kk'}$$
 Eq. 2

$$D_k = \max_{i,j \in I_k \ i \neq j} ||M_i^{\{k\}} - M_j^{\{k\}}||$$
 Eq. 3

$$d_{max} = max_{1 \le k \le K} D_k$$
 Eq. 4

$$C = \frac{d_{min}}{d_{max}}$$
 Eq. 5

Where:

- $d_{kk'}$ is the distance between clusters C_k and $C_{k'}$, measured by their closest points, where K is the number of clusters.
- d_{min} is the smallest of the distances $d_{kk'}$.
- D_k is the largest distance separating two distinct points in the cluster, also known as the diameter of the cluster.
- d_{max} is the largest of the distances D_k .

2.2.2 PBM Index

The aim of this metric is to identify the best number of clusters to be returned by a clustering algorithm. The index is calculated by finding the distances between every data point to their centroid and the distances between the centroids themselves. This is also used in the evaluation section and compared the Dunn's Index. [3]

The PBM Index is calculated using Eq. 9 below.

$$D_B = \max_{k < k'} d(G^{\{k\}}, G^{\{k'\}})$$
 Eq. 6

$$E_W = \sum_{k=1}^{K} \sum_{i \in I_k} d(M_i, G^{\{k\}})$$
 Eq. 7

$$E_T = \sum_{i=1}^{N} d(M_i, G)$$
 Eq. 8

$$C = \left(\frac{1}{K} * \frac{E_T}{E_W} * D_B\right)^2$$
 Eq. 9

Where:

- D_B is the largest distance d between two cluster barycenters (centroids), $G^{\{k\}}$. Where K is the number of clusters.
- E_W is the sum of distances of the points of each cluster to their barycentre.
- E_T is the sum of the distances of all the points to the barycentre G of the entire dataset.

2.3 K-Means

K-Means is one of the most common clustering algorithms. The main goal of K-Means is to cluster N vectors into K partitions, where $K \leq N$. K-Means tries to minimise the sum of distances of each vector to their respective cluster centroids, so that clusters are far apart but the vectors within each cluster are compact. [4]

2.3.1 Method

K-Means first starts with *K* non-equal points, which could be determined using various methods. These first *K* points are treated as the cluster centroids.

Each vector is then assigned to the nearest centroid, the distance between a vector and a cluster centroid can be calculated using different methods, for example by using Euclidean or Cosine distance metrics.

The centroids are then re-calculated and the membership of each vector is re-computed. This is done until the membership in the clusters is not changed in an iteration or a stopping condition is reached, as discussed in section 2.3.2. [4]

2.3.2 Limitations

K-Means keeps re-calculating the centroids and recomputing the membership of each vector until the clusters stop changing. This may take a lot of time so other stopping conditions are implemented, for example a maximum number of iterations is specified by the user. The main problem of the K-Means function is how the initial centroids are chosen, this can either be the first K vectors or a random K vectors from the dataset. If the chosen initial centroids are vectors which are close to each other or one of the chosen vectors is a document which has no other vectors close to it, the K-Means algorithm will not be very effective when clustering. It is usually difficult to determine the initial centroids because no knowledge about the dataset is known before clustering.

Another common problem when using K-Means to cluster documents, is determining the value of K. To solve this problem other algorithms can be used to determine the best K value for a particular dataset. Examples of such algorithms are explained in section 2.2.1.

2.4 No-K-Means

The No-K-Means algorithm is a clustering algorithm inspired by the K-means algorithm. Similar to the K-Means algorithm, the aim of No-K-Means is to cluster vectors, where each cluster contains vectors with minimised distances between them, and all clusters centroids are as different as possible.

Unlike K-Means, No-K-Means doesn't need to have the resulting amount of clusters, K, specified beforehand, thus taking care of the problem regarding which initial centroids to choose for the clusters. [5]

2.4.1 Method

No-K-Means starts with an empty list of clusters, and then creates a new cluster for the first vector to be clustered, with the vector being the cluster centroid.

Every other vector is compared to every existing cluster. If the similarity between the vector and the most similar cluster is below than a specified threshold, then a new cluster is created with that vector as its centroid. Otherwise the vector is added to that cluster, and the cluster centroid is recomputed by calculating the average of the corresponding vector values of the cluster. [5]

2.4.2 Limitations

Despite the fact that No-K-means doesn't require the number of clusters to be specified, it still requires some threshold to be specified, for when deciding whether to create a new cluster or not.

The alteration of the cluster centroids when being recomputed may vary, as it depends on which order the vectors are inputted to the algorithm. This makes the results of No-K-Means dependent on the vector input order.

2.5 Self-Organising Maps

Self-Organising Maps are Neural Networks which, as the name implies, are able to manipulate their own structure when stimulated with an input. The network usually consists of a 2-dimensional array of units, each of which is assigned a vector of weights. The values of these units are altered depending on the different inputs during the training stage. The clustering process then makes use of these weights in order to collect the inputs. [6]

2.5.1 Method

The size of the input vectors is first taken as l. An n by m neural network is initialised, with each neuron having a vector of l weights with random values. A number of iterations k are defined to limit how long the training procedure takes.

For every iteration, all training inputs are fed to the network in sequence. For each input, the best matching unit, (BMU), (i.e. the neuron with weights having the least distance from the input) is calculated. The topological neighbourhood, N, of the BMU is calculated using a neighbourhood function. The weights of the BMU and the units in N are modified, using a learning function, to approach those of the input. Euclidean distance was used as the distance function. [6]

The clustering process takes place after the training is finished. A simple technique is adopted for the purpose of this assignment. To cluster the inputs, best matching unit for each is calculated, and the inputs with the same *BMU* are collected as a cluster.

2.6 Spectral Clustering

Spectral Clustering has been widely used in recent years and has become one of the most popular algorithms to use. This can be attributed to the simplicity to implement such a system along with results which usually perform better than other algorithms. Spectral clustering makes use of eigenvalues of a similarity matrix to perform dimensionality reduction. After which the resultant data will be clustered. [7]

2.6.1 Method

The first step to implement such a clustering algorithm is to create a similarity matrix. This is done by finding the similarities between all pairs of data points into a graph. In our implementation we are using an unnormalised graph Laplacian Matrix to represent this graph into a matrix. All the eigenvectors of the Laplacian Matrix are calculated and kept in another matrix. Finally the matrix with

eigenvectors is clustered using the K-Means algorithm. To find the best number of clusters for the K-Means algorithm we use metrics for evaluating the functions. The two metrics used are described above, Dunn's index and PBM index.

3. Clustering Implementation

In this section, the implementations of the algorithms along with certain limitations with respect to the Chrome extension developed are discussed.

3.1 K-Means

For the purpose of this task, a JavaScript implementation of the K-Means algorithm was found and modified to fit the needs of this task [8].

The K-Means used in the extension was evaluated using two methods to determine the best value of K. The two methods are the Dunn's index explained in section 2.2.1 and another method, where if the dataset contained more than a single Wikipedia search result, the Wikipedia search results were used as the initial centroids and K was changed to the amount of Wikipedia search results. It is assumed that Wikipedia typically contains a different page for each different sense of a term, hence one can assume the different Wikipedia search results to refer to different senses. However, the Dunn's index was not used in the extension since it was not feasible given that it greatly increases the clustering time. The method using Wikipedia search results produced better results when the algorithm was evaluated using the gold standard dataset.

The implemented K-Means was also tested using Euclidean distance and Cosine distance, where the cosine distance also produced better results when clustering sparse vectors.

The current implementation of K-Means currently uses cosine distance as a distance measure and the Wikipedia search results to choose the initial centroids. This can be clearly seen in Figure 7, where the algorithm found two Wikipedia search results, one on jaguar the car brand and the other Wikipedia search result on jaguar the animal. The algorithm set K to 2 and used the two Wikipedia search results as the initial centroids. If there is only one Wikipedia search result in the dataset, the initial centroids are chosen at random and the default value of K, 5, is used.

3.2 No-K-Means

For No-K-Means, the similarity between input vectors and cluster centroids was computed using the cosine similarity equation.

For the best results, a threshold of 0.05 was used when the algorithm gets to decide whether to create a new cluster or not. Since no cluster analysis methods are implemented in the extension, this threshold had to be fixed. This choice was based on a number of tests using results from the Google search engine. In addition, it was observed that the algorithm performed best with this threshold, as explained in section 6.4.

3.2.1 Limitations

In order to find the ideal threshold, cluster analysis could be performed, such as by using Dunn's Index. When using Dunn's Index with the K-Means algorithm, the time cost was expensive, hence it was not feasible to include it in the extension's No-K-Means implementation.

3.3 Self-Organising Maps

For the purpose of this task, a JavaScript implementation of a Self-Organising Map was found [9].

3.3.1 Limitations

Due to the expected response time, certain limitations to the quality of the results had to be imposed on the implementation.

Ideally, the parameters for the algorithm are not fixed, but determined using Dunn's or PBM Indices. This, however, is not feasible as it greatly increases the computation time for the algorithm.

After testing with several input arguments (mainly varying the number of iterations and the network size), the ideal values for these parameters were taken based on the computation time and the quality of the results. The choice of these values is discussed in section 6.5.

Another issue with the implementation is that the distance metric used is Euclidean. While Cosine distance was considered, and tested, this required more sophisticated clustering methods, such as using a U-Matrix [6]. These, however, were not found available in JavaScript, and the implementation was limited to a simple clustering technique.

3.4 Spectral Clustering

Due to the fact that libraries for the Spectral Clustering algorithm were not available in JavaScript it was decided to use MATLAB [10]. As a result, it was not feasible to include this algorithm with the Google Chrome extension.

3.4.1 Limitations

In the MATLAB Implementation a cosine similarity matrix was tested but did not work with our data

since it resulted in a singular matrix. This was attributed to the fact that our data was sparse.

4. The Google Chrome Extension

The developed Chrome extension aims to group the top hundred search results returned from the Google search engine when and if requested by the user. This should be helpful to distinguish between results corresponding to different senses of an ambiguous query phrase. For example, search results for "jaguar" may be referring to a car manufacturer, a type of cat, or other possibly meanings of the same word.

In this section, the development of the product is discussed and examples of its usage are given.

4.1 Development of the Artefact

The chrome extension is split into 3 main parts, the background script, the main script and the popup HTML page which uses the popup script. The background script monitors the current URL and if the URL is equal to a google search URL the extension then enables itself and allows the user to choose a clustering method. Once the user chooses a clustering method the extension clusters the Google results, and displays the clusters, as shown in Figure 3, instead of the Google results.

4.1.1 The Background Script

The background script is kept in memory and monitors the current URL. Once the URL is a Google search URL, the background script adds 2 parameters to the URL to force Google to display 100 results in a single page and to disable auto complete, which is enabled by default. The background script then enables the chrome extension, which the user can see as the chrome extension icon becomes coloured.

4.1.2 The Popup Page and the Popup Script

The purpose of the popup page is to serve as the user interface, where once the user clicks on the extension icon the popup page is displayed as a dropdown window as can be seen in Figure 1. From the popup page the user is allowed to choose the algorithm, which he wishes to use for clustering as can be seen in Figure 2. The popup page also contains a button called "Cluster Results" which the user can click once he has chosen the clustering algorithm. Once the button is clicked the popup script constructs a configuration object, containing all the options the algorithms use. The popup script then accesses the background page and sends the

configuration object to the main script, which starts the clustering process.



Figure 1 Popup Menu

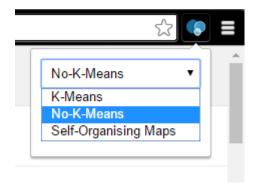


Figure 2 Popup Menu - Clustering Algorithms

4.1.3 The Main Script

The main script first fetches the google search results and performs pre-processing on the results. The algorithm then calls the respective clustering algorithm to perform clustering. After the algorithm is done clustering the main script also displays the results in place of the actual google results.

4.2 Information Pre-Processing

Pre-Processing occurs in the main script. Before clustering the main script pre-processes the results, to remove stop words, and stem the remaining words. Stop words are words which are too frequently occurring across different documents. An example of a stop word is the determiner "the" which will not be useful to distinguish between documents. Stemming is the process of reducing words to their stems, e.g. "connect" is the stem for "connecting", "connected", "connection" etc... The main script first obtains the google search results, and excludes any results containing images. The pre-processing function then uses the title and content of each search result, converts them to lower case and removes any symbols using a regular expression. It then calls the stemming function which uses an implementation of Porter's stemmer [11]. The stemming function then stems the query terms, the stop words, which is a pre-defined list of stop words [12], and stems the list of words obtained from the google search results. The function then removes any stop words and query terms which occur in the list of words obtained from the google search results. The remaining words are then used to build a histogram template. The histogram template is a blank histogram with no word frequencies which the algorithm can use to keep the same order of words when constructing the histogram for each search result. The histogram template is then used to create a word histogram for each search result, which is made up of words and their frequencies.

4.3 Clustering of Results

After the feature vectors are passed to the algorithm in question, the function returns a list of clusters, each containing a list of search results, including the original HTML. These snippets are used to construct the clustered results in the Google results page itself. Every cluster is collapsed, leaving only one significant result appearing, as shown in Figure 3. The user is then able to expand and collapse the results in the cluster, as shown in Figure 4. Every cluster is labelled with a query which attempts to summarise the contents of the cluster. This query is clickable, and forwards the user to a new Google search. The query is constructed by appending the most occurring word in the cluster (i.e. the word/s appearing most in the cluster documents) to the original query.



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Figure 4 Results in an expanded cluster.

5. Testing

In this section, the three algorithms implemented in the extension are tested using two different queries; "fish and chips" and "jaguar". The first query phrase is not ambiguous like the second, however it is shown below that the extension is able, at different degrees, to cluster similar results for this query as well; for example by grouping results referring to restaurants and those referring to recipes. For the second query, results are expected to contain links to websites concerning different meanings of "jaguar". The following tests show how the algorithms perform at handling this ambiguity.

In addition, the depth at which the system is able to keep clustering search results is examined for each algorithm. This is done by searching for similar results to particular clusters and clustering the new results again.

The time taken for each algorithm to cluster the results is also examined.

5.1 K-Means

5.1.1 Test 1 – Search Query "fish and chips"

As can be seen in Figure 5, K-means did not manage to find more than one Wikipedia search result and used the default value of K. This resulted in five clusters.

As can be seen in Figure 6 the expanded cluster titled "fish and chips recipe", most of the documents in that particular cluster are about recipes.

5.1.2 Test 2 – "jaguar"

As can be seen in Figure 7, K-Means found 2 Wikipedia search results; one on jaguar the animal, the other one on jaguar the car, it then used these as the initial clusters and used K = 2. This results in two clusters one on cars the other one on animals. As can be seen Figure 8 the documents in the expanded cluster named "jaguar cat" are mostly about animals.

5.1.3 Depth Clustering

The first depth clustering test was done by refining the query to "jaguar cat", and the new results where re-clustered. The result can be seen in Figure 9 and in Figure 10 one can see the documents in one of the clusters titled "jaguar cat wild", where the documents in this particular cluster are mostly about the wild animal.

The second depth clustering test was done by refining the query to "jaguar cat wild", and the new results where re-clustered. The results of this re-clustering can be seen in Figure 11 and in Figure 12 one can see one of the expanded clusters titled

"jaguar cat wild habitats", where the documents in this particular cluster are mostly about the habitat of the wild animal.

The third and final depth clustering test was done by refining the query to "jaguar cat wild habitats", and the new results where re-clustered. The results of this re-clustering can be seen in Figure 13 and in Figure 14 one can see the documents in one the expanded clusters titled "jaguar cat wild habitat protecting", where the documents in this particular cluster about the title "jaguar cat wild habitat protecting" are considerably less.

5.2 **No-K-Means**

No-K-Means was tested using the search query "fish and chips", in order to examine the speed and quality of the clustering, and also using the search query "jaguar", mostly to examine the depth of clustering.

As shown in Figure 15, the clustering took just 0.581 seconds. The figure also shows the usefulness of clustering, since the user is able to choose which category to browse. For example, in this example, one can expand the "fish and chips recipe" or the "fish and chips restaurant", depending on the user's interest.

In Figure 16, a cluster with similar query "fish and chips restaurant" is expanded, and it can be clearly shown that every search result in this cluster is about a specific restaurant, or restaurants. This shows great clustering quality in order to fit the user's interest.

In Figure 17, searching the term "jaguar" and clustering the results gives good unambiguous results. The algorithm took even less time, i.e. 0.445 seconds. As before, the results clusters seem to be quite sensible, where the results are categorised as cars, cats, and even restaurants.

In Figure 18, the depth of clustering is increased, by re-clustering a search query, "jaguar cats", which was extracted from a cluster in the previous clustering.

Figure 19 - Figure 22 show clustering depth, where 6 clusters are reduced to just 1 cluster, due to the increased similarity between the remaining search results. The search query became very specific ("jaguar cats southern arizona 2016 wild mexico sonora"), referring to a specific event where a very rare jaguar was seen in Southern Arizona, Sonora, Mexico.

5.3 Self-Organising Maps

Since the SOM algorithm is not deterministic, as the initial network weights are randomised, the clustering of the results may vary from one

execution to another, even when given the same training vectors.

As evident in Figure 23, SOM took just over 1 second to cluster the results with the fixed parameters (5 iterations and a network width of 5).

The clusters feature different topics which may be of interest to different users or at a different time. For example, the second cluster is labelled "fish and chips restaurant" while the last cluster is labelled "fish and chips recipe". These may be relevant to different users; those who are looking for some place to eat, and others searching for a method to cook.

In Figure 24, it is evident that the results in the 'restaurant' cluster are actually all restaurants which serve fish and chips or have "fish and chips" in their name.

For the second query, "jaguar", SOM took around 1.5 seconds to cluster the results with the fixed parameters. This is shown in Figure 25.

The proposed queries for similar searches for the clusters, however, seem less sensible than before. A number of clusters seem to be referring to the Jaguar automobiles while only one cluster for "cats" was created. This is examined in Figure 26.

In Figure 26, it is shown that the top 10 results in the "jaguar cats" cluster contain a majority of the documents related to cats, one result related to an American football team and one related to a Jaguar particular car model.

If the user decides to continue searching using the "Similar" functionality with the "jaguar cats" query, and clusters the results once again, output similar to that in Figure 27 should be expected.

As evident, the number of clusters is greater for this particular search query, however some appear to be close to each other, such as "jaguar cats America" and "jaguar cats Americas", and the three clusters with a similar query "jaguar cats tiger".

From the above and other tests, it was noted that SOM was more effective when the search query is specific, such as "fish and chips", and thus useful for queries which are not ambiguous.

5.4 Discussion

When there was minimal ambiguity in the query phrase, the three algorithms managed to give satisfactory results when clustering the google search results. When the search query was ambiguous the SOM algorithm was not as suitable at clustering the search results as the other algorithms. This is due to the quality of the clusters and the time taken to perform the clustering, which was longer than 1 second.

When depth clustering was performed, both the K-Means and the No-K-Means algorithms managed to produce good clusters which had a good refined query phrase (similar query link). The No-K-Means algorithm managed to perform better in depth clustering, since it managed to reduce the documents to one cluster after the query was refined.

6. Evaluation

The four clustering algorithms (the above three and Spectral Clustering using MATLAB), were evaluated using a specific dataset. This allows the determination of the fittest algorithm for the type of data we are considering, i.e. results from a search engine.

In this section, the gold standard used in the evaluation is described, followed by an overview of the evaluation metrics. The evaluation of each of the four clustering algorithms is then discussed.

6.1 The SemEval 2013 Task 11

SemEval is a collection of evaluations of computational semantics and is concerned with the meaning of language.

SemEval-2013 Task 11¹ is concerned with grouping search result snippets into clusters where the results in each cluster have similar semantic meaning, and each cluster has its own meaning of the search query.

The organiser of this task, Navigli et al. [2] created a gold standard collection which contains 100 search queries about ambiguous topics. These queries were then searched using Google search engine, retrieving 64 results for each query. The results were then manually organised into groups, classified by the topic, and every result was represented by its URL, title and snippet.

An automated evaluator was provided in order to determine the accuracy of any search clustering results, which is evaluated using the values F1, Rand Index, Adjusted Rand Index and Jaccard Index.

6.2 Scoring and Measures

In this section, the sample space *S* represents all the documents to be clustered, while sets *X* and *Y* refer

¹ https://www.cs.york.ac.uk/semeval-2013/task11/

to the list of clusters generated by the algorithm and the list of clusters of the SemEval 2013 Task 11 dataset.

Subsets $\{X_1, X_2, ..., X_i\}$ and $\{Y_1, Y_2, ..., Y_j\}$ refer to the clusters of documents of X and Y respectively.

6.2.1 F1

The F1 score is an accuracy measure of two data sets, were the result is a value between 0 and 1, 0 being the worst possible value while 1 being the best.

Precision is defined as the number of positive cases which were predicted positives divided by the number of all the predicted positives.

Recall is defined as the number of positive cases which were predicted positives divided by the number of all the positive cases.

In this case the positive cases of a cluster are the documents of the cluster according to the SemEval 2013 Task 11 dataset, while the predicted positives are the documents of the cluster according to the clustering algorithm being used.

F1 is then calculated as the weighted product of precision and recall, divided by the sum of precision and recall, given by Eq. 10:

$$F_1 = \frac{{\scriptstyle 2\times precision\times recall}}{{\scriptstyle precision+recall}} \hspace{1cm} \text{Eq. 10}$$

6.2.2 Rand Index

Two sets X and Y, which are the subsets that make up sample space S, can be divided into subsets $\{X1, ..., Xi\}$ and $\{Y_1, ..., Y_i\}$ respectively.

The number of pairs of elements in S which are in the same set in X and in the same set in Y, is denoted as a.

The number of pairs of elements in S which are in different sets in X and in different sets in Y, is denoted as b.

The addition of these values, i.e. a + b, gives the number of agreements between X and Y.

The number of pairs of elements in S which are in the same set in X and in different sets in Y, is denoted as c.

The number of pairs of elements in S which are in different sets set in X and in the same set in Y, is denoted as d.

The addition of these values, i.e. c + d, gives the number of disagreements between X and Y.

Rand index is defined as the number of agreements divided by the sum of the number of agreements and the number of disagreements, given by Eq. 11:

$$R = \frac{a+b}{a+b+c+d}$$
 Eq. 11

The rand index is also a value between 0 and 1.

6.2.3 Adjusted Rand Index

Two sets X and Y, which are subsets of the sample space S, can be divided into subsets $\{X_1, ..., X_i\}$ and $\{Y_1, ..., Y_j\}$ respectively, which can be summarised in the following table:

X/Y	Y ₁	\mathbf{Y}_2		Yj	Sums
X ₁	n ₁₁	n ₁₂		nıj	a_1
X_2	n ₂₁	n ₂₂		n _{2j}	a_2
•		•	-		•
Xi	nil	n _{i2}		n _{ij}	a _i
Sums	b ₁	b_2		b _j	n

where n_{ij} is the number of common objects in the corresponding sets, given by:

$$n_{ij} = |X_i \cap Y_j|$$
 Eq. 12

The adjusted rand index is defined as the following:

$$ARI = \frac{\sum_{ij} {n_{ij} \choose 2} - \frac{\sum_{i} {n_{ij} \choose 2} \sum_{j} {b_{j} \choose 2}}{{n \choose 2}}}{\frac{1}{2} [\sum_{i} {n_{i} \choose 2} + \sum_{bj} {b_{j} \choose 2}] - \frac{\sum_{i} {n_{i} \choose 2} \sum_{j} {b_{j} \choose 2}}{{n \choose 2}}}$$
Eq. 13

6.2.4 Jaccard Index

Jaccard index compares the similarity of two data sets, X and Y by dividing the number of intersecting elements in the sets by the size of the union of the sets, given by:

$$J(X,Y) = \frac{|X \cap Y|}{|X \cup Y|}$$
 Eq. 14

This gives a value between 0 and 1, where 0 means that no elements in one set can be found in the other while 1 means all elements of one set can be found in the other.

6.3 K-Means

The K-Means implementation was tested using search results from the gold standard dataset. The algorithm was tested using 4 different cases, in each case the algorithm was tested multiple times with different values of K, the best result in each test case is displayed in the Table 1.

The K value is the number of clusters which the K-Means algorithm should produce if it does not manage to meet certain conditions. This is mainly used in the Wikipedia search results method where if the algorithm does not manage to find more than

1 Wikipedia search results it uses the default K value to find random initial centroids.

In the case when the Wikipedia search results are not considered the number of clusters is set to the default K value.

Table 1 F1, RI, ARI and Jaccard scores for K-Means using WikiPedia and Dunn's Index.

	K	F1	RI	ARI	JI	Avg.	Avg. # Clusters	Avg. Cluster size
Using Wikipedia	3	0.68	0.65	0.21	0.35	0.47	5.92	15.24
Without Wikipedia	9	0.70	0.62	0.14	0.20	0.42	9	7.11
Dunn's Index - Using Wikipedia	/	0.63	0.59	0.08	0.20	0.38	7.71	10.75
Dunn's Index - Without Wikipedia	/	0.63	0.59	0.08	0.20	0.37	7.49	10.95

The first case was using Wikipedia search results as the initial centroids if the amount of Wikipedia search results was greater than 1, this also meant that the value of K changed each time to the amount of Wikipedia search results. If the algorithm only found one Wikipedia search result it used a default value for K for this particular case which was 3. This case produced the best results.

The second case the algorithm produced the best results with the default value for K for this particular case which was 9. In this case the algorithm used random documents as the initial centroids.

The third case, the algorithm was tested using an implementation of Dunn's index and using Wikipedia search results as the initial centroids. Where if the algorithm does not find more than 1 Wikipedia search result, the algorithm uses the K value determined by the Dunn's index. If the algorithm manages to find more than one Wikipedia search results the amount of Wikipedia search results overrides the K value.

The fourth case, the algorithm was tested using an implementation of Dunn's index where the initial centroids where random documents.

6.4 **No-K-Means**

In order to evaluate the No-K-Means algorithm, different threshold values were passed to it, in order to determine the threshold for the best results.

Cosine similarity between two text vectors can only vary from 0 to 1, thus for evaluation, thresholds from 0 to 1 were passed, at intervals of 0.01, which sum up to 100 different thresholds.

The following table shows the top five results:

Table 2 F1, RI, ARI and Jaccard scores for No-K-Means.

t	F1	RI	ARI	JI	Avg.	Avg. #	Avg.
						Clusters	Cluster
							Size
0.05	0.72	0.69	0.28	0.36	0.51	7.8	9.01
0.04	0.7	0.68	0.27	0.37	0.51	7.12	9.86
0.06	0.73	0.69	0.27	0.34	0.51	8.28	8.59
0.07	0.74	0.69	0.26	0.33	0.51	8.73	8.12
0.08	0.74	0.69	0.26	0.32	0.50	9.02	7.79

This shows that the best results are obtained with a threshold of 0.05, and that the threshold values of the top five results are all similar.

When testing the algorithm with a threshold of 0.05, the maximum Rand Index (RI), 0.69, and the maximum Adjusted Rand Index (ARI), 0.28, were obtained. The maximum F1, 0.76, was obtained with a threshold of 0.15, and the maximum Jaccard Index (JI), 0.4, was obtained with a threshold of 0. However, when calculating the average of the four scores, the maximum average score, 0.51, was obtained with the threshold value 0.05.

6.5 Self-Organising Maps

The results yielded by the algorithm for the SemEval dataset were evaluated by the following procedure.

The number of iterations, *i*, was varied between 5 and 20, and a square network of width, *w*, varying from 3 to 25 was used. The results were documented and the following table shows the top three.

Table 3 F1, RI, ARI and Jaccard scores for SOM.

i	w	F1	RI	ARI	JI	Avg.	Avg. # Clusters	Avg. Cluster Size
8	23	0.68	0.61	0.15	0.25	0.42	4.80	13.49
8	21	0.68	0.61	0.15	0.25	0.42	4.89	13.30
7	19	0.68	0.61	0.14	0.25	0.42	4.82	13.45

The above results indicate that the optimal parameters for using the Self-Organising Map with the data in question are a network width of 23 and a limit to 8 iterations.

This is, however, unfeasible for the purpose of our extension, as the training takes seconds, or even minutes, to finish.

In light of this, a sub-optimal choice of parameters was taken, without radically reducing the effectiveness of the algorithm. Both the number of iterations and the network width are locked at 5. This decision was based on a number of tests on data retrieved from the Google search engine.

The table below shows the values for F1, Rand Index, Adjusted Rand Index and Jaccard Index metrics for SOM with the 5 iterations and a network width of 5, and how these compare to the top results.

Table 4 F1, RI, ARI and Jaccard scores for SOM.

i	w	F1	RI	ARI	JI	Avg.	Avg. # Clusters	Avg. Cluster Size
8	23	0.68	0.61	0.15	0.25	0.42	4.80	13.49
8	21	0.68	0.61	0.15	0.25	0.42	4.89	13.30
7	19	0.68	0.61	0.14	0.25	0.42	4.82	13.45
5	5	0.69	0.60	0.12	0.21	0.40	6.53	10.44

6.6 Spectral Clustering

The algorithm was tested using the SemEval gold standard query data. Tests for spectral clustering were conducted with 2 different indices, each index was implemented with 2 different distance functions, Euclidean and Cosine distance. Spectral clustering has one parameter, the Sigma. Multiple tests were conducted with Sigma ranging from 0-10 in increments of 0.1. These tests were also run for the 4 indices explained above. The clustered data is evaluated by 4 metrics F1, Rand Index, Adjusted Rand Index and Jaccard Index. The Average of these indices is calculated to identify the best parameter for the algorithm. The table below shows the top test results and it concluded that the best index was PBM with cosine distance having an average of 0.393 and the worst was Dunn's index with cosine distance having an average of 0.367. The best sigma for PBM with cosine distance was 0.9.

Table 5 F1, RI, ARI and Jaccard scores for Spectral Clustering using PBM and Dunn's Indices, and Cosine and Euclidean Distances.

	Sigma	F1	RI	ARI	JI	Avg.	Avg. # Clusters	Avg. Cluster Size
PBM Cosine	0.9	0.70	0.55	0.06	0.26	0.39	19.23	4.36
PBM Euclidean	1.3	0.63	0.54	0.05	0.29	0.38	10.97	8.44
Dunn's Cosine	0.7	0.62	0.49	0.04	0.32	0.37	9.69	10.78
Dunn's Euclidean	1.3	0.63	0.54	0.05	0.29	0.38	10.97	8.44

6.7 Discussion

After evaluating the algorithms using the SemEval 2013 Task 11 dataset, it was evident that the No K-means Algorithm performed better than the others. This was concluded by comparing the average of the F1, Rand Index, Adjusted Rand Index and Jaccard Index, where No-K-Means achieved an average of 0.51, while K-Means, SOM and Spectral Clustering achieved averages of 0.47, 0.42 and 0.39, respectively.

7. Limitations and Future Work

In section 3, it is mentioned that the algorithms implemented in the extension do not perform any cluster analysis. The reason for this is that performing cluster analysis by using, for example, Dunn's Index or PBM Index to identify the best set

of clusters, would highly increase the computation time, especially when the number of varying parameters is more than one. This is not practical as the user expects the system to operate in real-time.

As described in section 4.3 the Google Chrome extension has a clickable link that restructures the query for the Google search to reflect that cluster. It would be a future improvement to explore the restructuring of the query such that the change in performance can be compared. One such method to restructure the query would be to add the query label for the selected cluster and also negate the other cluster query terms. For example, "fish and chips recipes –restaurants" to include results referring to recipes, but excluding those related to restaurants. In addition, currently we are extracting the cluster label by picking the most frequent word in that cluster. It would be more beneficial to identify and implement a more effective labelling algorithm.

Another point, that could make the extension more user-oriented, is to identify ways to rank clusters so that the clusters presented to the users are ordered in a more logical way. In addition to this, it would be beneficial to use data available in the Google Chrome framework, such as browser history and bookmarks, and rank clusters depending on the user model.

8. Division of Work

In this section, the roles of each member of the group are defined. The work was fairly divided, with some focusing more on the development of the extension and others on the research and improvements of the clustering algorithms.

8.1.1 Apap Adrian

During the course of this project I contributed to the implementation of modules of the google chrome extension and implemented the pre-processing methods used before clustering is performed. I also researched K-Means and modified a JavaScript implementation of K-Means to work with the chrome extension.

8.1.2 Buhagiar Juan

During the first phases of the project I researched and tried to implement the Gaussian Mixture Models algorithm. Due to certain limitations of this algorithm it was decided to find another algorithm. Spectral clustering was chosen to replace GMM. Testing was done with spectral clustering and I also implemented two indices Dunn's and PBM index.

8.1.3 Falzon Alan

At the early stages of the project, I searched for JavaScript implementations of K-Means, Self-Organising-Map and Gaussian Mixture Models. My work mostly consisted of the implementation of the No-K-Means search results clustering algorithm. I also researched the F1 score, Rand Index, Adjusted Rand Index and Jaccard Index.

8.1.4 Schembri Yurgen

My role during the development of this project was to implement the post-processing methods (i.e. output of the clusters). With regards to the research aspect, I investigated Self-Organising Maps and modified the JavaScript implementation adopted for this assignment. In addition, I prepared scripts for automating the extraction of results from the SemEval evaluator for easier evaluation.

9. Conclusion

The paper outlines the process that was taken to design and implement a system, which enables users to identify better a set of relevant web pages, using search result clustering. As described, there are several algorithms that cluster data, we have performed tests and evaluation to identify the best algorithm for textual clustering analysis. Using the developed browser extension, tests were performed on real data from google searches which gave promising results. The evaluation process, with the SemEval 2013 Task 11 Dataset, provided a more scientific way to interpret results from the tested algorithms, with the help of the F1, Rand Index, Adjusted Rand Index and Jaccard Index. It was concluded, based on results obtained above, that the No-K-Means algorithm has given the best overall results.

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 xt. [Accessed: 16- May- 2016].
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10.1 K-Means Testing Screenshots fish and chips All Maps Images Videos News More ▼ Search tools About 122,000,000 results (0.81 seconds) | Results clustered in 5 clusters (0.046 seconds) Similar: fish and chips restaurant Expand Cluster Chatham Fish and Chips, Seafood Restaurant and Takeout Seafood chathamfishandchips.com/ ▼ Chatham Fish & Chips is a family owned and operated casual seafood restaurant, with indoor and outdoor seating. Chatham Fish and Chips will take your Similar: fish and chips free history Expand Cluster Fish and Chips: A History: Panikos Panayi: 9781780233611: Amazon ... www.amazon.com > ... > Cooking by Ingredient ▼ Amazon.com, Inc. ▼ Fish and Chips: A History [Panikos Panayi] on Amazon.com. "FREE* shipping on qualifying offers. Double-decker buses, bowler hats, and cricket may be ... Similar: fish and chips mac god Expand Cluster Mac's Fish & Chip Shop - Santa Barbara Welcome to MAC'S, an authentic British Fish & Chip shop in Santa Barbara, California where cod is our god, batter matters, mushy peas please, chips are hip ... Similar: fish and chips shop menu serving

www.thefishandchipshop.com/ =
The Fish & Chip Shop is a British-style fish and chip restaurant in Portland, Oregon. We strive to serve the very best fish and chips with traditional sides, as well ...

Fish and Chips Recipe (English batter-fried fish with fried potato ...

The Fish & Chip Shop - Portland

Similar: fish and chips recipe

Onlips Recipe (Linguist) better into the manner of the man

Figure 5 "fish and chips" clustering results



Fish and Chips Recipe: Tyler Florence: Food Network
www.foodnetwork.com; Recipes & How-Tos * Food Network *
****** Rating: 4.6 - 111 reviews - 40 min
Tylers Fish and Chips.... Dredge the fish pieces in the rice flour and then dip them into
the batter, letting the excess drip off. ... Fry the fish and chips for 4 to 5 minutes until

Fish and Chips Recipe : Jamie Oliver : Food Network www.foodnetwork.com : Recipes & How-Tos ▼ Food Network ▼
★★★★ Raing: 4.5 - 31 reviews - 23 min
Get this all-star, easy-to-follow Fish and Chips recipe from Jamie Oliver.

Chips and Fish Recipe: Alton Brown: Food Network

www.foodnetwork.com; Recipes & How-Tos * Food Network *

*** Rating: 4.4 - 164 reviews - 50 min
Get this all-star, easy-to-follow Chips and Fish recipe from Alton Brown.

English-Style Fish and Chips Recipe: Tyler Florence: Food Network www.foodnetwork.com > Recipes & How-Tos * Food Network *

**** Rating: 4.6 - 67 reviews - 1 hr 5 min
Get this all-star, easy-to-follow English-Style Fish and Chips recipe from Tyler Florence.

Fish and Chips | Williams-Sonoma www.williams-Sonoma v For perfectly crisp and golden deep-fried food, it is essential to maintain the oil at the correct temperature. Use a deep-frying thermometer and adjust the heal to ...

Fish and Chips recipe | Epicurious.com
www.epicurious.com/recipes/food/../fish-and-chips-109011 ▼ Epicurious ▼
****** * Rating: 3/4 - 53 reviews - 6/42 cal
Per plotates and have lengthwise, then cut lengthwise into 1/2-inch-thick wedges,
rensferring as cut to a large bowl of ice and cold water. Chill 30 minutes.

Baked Fish and Chips Recipe - NYT Cooking cooking.nytimes.com/recipes/1018023-baked-fish-and-chips v ***** Rating: 5 - 247 votes - 1 hr - 907 cal

Figure 6 "fish and chips recipe" cluster

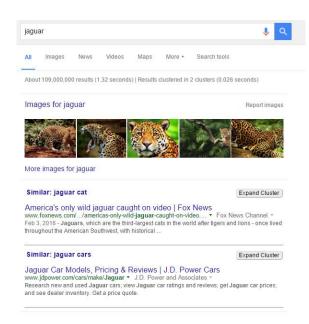
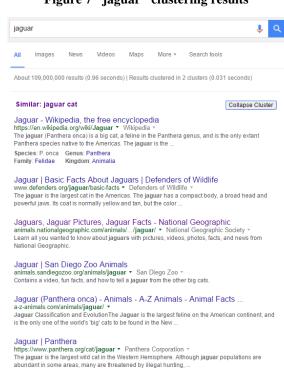


Figure 7 "jaguar" clustering results



Jaguar (Panther onca) | Rainforest Alliance
www.rainforest-alliance org/kids/species-profiles/jaguar * Rainforest Alliance *
Jaguars can reach up to six feet in length - from their nose to the tip of their tail -- and stand up to
three feet tall at the shoulder. The average male jaguar weighs ...

Jaguar - Facebook

Jaguar - Facebook com/JaguarUSA
Jaguar. 12489344 likes · 6037 talking about this · 113 were here. Jaguar. The Art of Performance.

Jaguar - Center for Biological Diversity

www.biologicaldiversity.org/species/mammals/jaguar/

Center for Biological Diversity

After the iaguar was listed as endangered in the United States in 1997 in response to a Center

Figure 8 "jaguar cat" cluster

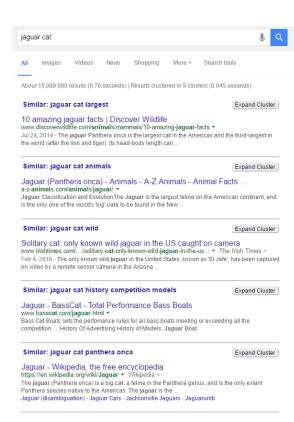


Figure 9 Depth Clustering test "jaguar cat" clusters

Similar: jaguar cat wild Collapse Cluster

Video shows only known wild jaguar in US at home in Arizona ...
www.theguardian.com > Environment > Wildlife ▼ The Guardian ▼
Feb 3. 2016 - The big cat, known as El Jefe', has been living in 25 miles south of downtown Tucson
– half a century after the last verified US jaguar was ...

Return of the Jaguar? | Science | Smithsonian www.smithsonianmag.com/science._/return-of-the-jaguar-110630052/ * Smithsonian ~ Novel camera traps have documented the elusive cat in Arizona, suggesting it may not be gone from the United States after all.

New Video Shows America's Only Known Wild Jaguar https://www.biologicaldiversity.org/.../Jaguar-02-03-20.... * Center for Biological Diversity * Feb 3, 2016 - Video of Arizona's Jaguar Is First Ever to Be Released to Public ... video of the jaguar, and it comes at a critical point in this cat's conservation.

Jaguar, the biggest wild cat of America | Rescued Costa Rican wild .

www.waterfallgardens.com/jungle_cats_jaguar.php = interact with our rescued Jaguars, Pumas, Ocelots, Margays and Jaguarundi in our jungle cat wildlife preserve where they live in natural habitats. Jaguar is the ...

Arizona jaguar? Photos show rare big cat near Tucson. - CSMonitor.com www.csmonitor.com/.../Arizona-jaguar-Photos-show-ra... ▼ The Christian Science Monitor ▼ Jun 28, 2013 - Arizona jaguar is seen in photos roaming the mountains southeast of Tucson. Federal wildlife officials provided the photos of the rare Arizona

Arizona's elusive, wild jaguar leads intriguing life - CNN.com www.cnn.com/2016/02/04/us/jaguar-arizona-wildlife-irpt/ ▼ CNN ▼

Feb 4, 2016 - "El Jefe." the only known wild jaquar living in the United States, made news Wednesday when video of the elusive cat was made public.

Costa Rica Wild Cats, Jaquar Ocelot Jaquarundi Margay Cat

Wild cats of Costa Rica: jaguars, ocelots, jaguarundis, margay cats and tigrillos

America's Only Wild Jaguar Caught on Video : Discovery News Feb 4, 2016 - For the first time, viewers are getting the chance to glimpse the secretive world of the big cat known as 'El Jefe.'

ESSENTIAL FOODS The Jaguar Cat Food, 3 kg: Amazon.co.uk: Pet https://www.amazon.co.uk/ESSENTIAL...Jaguar-Cat.../800N8K6JP... ▼ Amazon.com, Ir

Rating: 4.6 - 9 reviews
ESSENTIAL the JAGUAR is the optimum & luxurious food suggestion for cats and kittens of all sizes and breeds. A unique recipe containing 80% chicken,

Video captures rare glimpse of 'El Jefe,' perhaps the only remaining ...
https://www.washingtonpost.com/.../video-captures-rare-glimpse-of... The Washington Post ** Feb 4, 2016 - It's said that of all the world's big cats, jaguars are the only ones that can't be tamed. They have thick, muscular bodies, stocky limbs and ...

Rare Footage Captures America's Only Known Wild Jaguar

| America | America

Figure 10 "jaguar cat wild" cluster

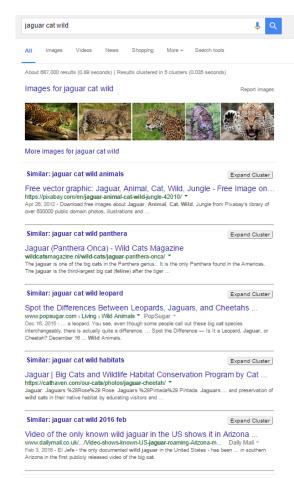


Figure 11 Depth Clustering test "jaguar cat wild" clusters

Similar: jaquar cat wild habitats

Collapse Cluster

Jaguar, the biggest wild cat of America | Rescued Costa Rican wild ... www.waterfallgardens.com/jungle_cats_jaguar.php * Interact With our rescued Jaguars, Pumas, Ocelots, Margays and Jaguarundi in our jungle cat wildlife preserve where they live in natural habitats. Jaguar is the ...

Arizona jaguar? Photos show rare big cat near Tucson. - CSMonitor.com www.csmonitor.com/.../Arizona-jaguar-Photos-show-ra... • The Christian Science Monitor • Jun 28, 2013 - "It's hard to see how an area with possibly the only jaguar living in the wild in the United States ... how that habitat would not be essential to ...

Jaguar | Big Cats and Wildlife Habitat Conservation Program by Cat ..

https://cathaven.com/our-cats/photos/jaguar-cheetah/
Jaguars M28Rose%29 Rose. Jaguars %28Pintada%29 Pintada. Jaguars ... and
preservation of wild cats in their native habitat by educating visitors and ...

The Jaguar Project :: Habitat Loss Prevention and Wild Cat ..

www.miengudanpiect.com/ THE JAGUAR ACCESS GATEWAY PROJECT is working to establish long-term conservation measures to protect the habitat of the jaguar and the five other felid ...

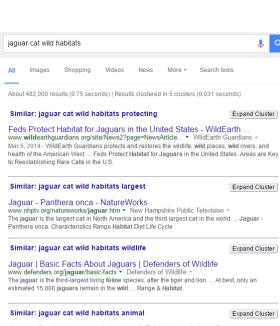
UA Wild Cat Research and Conservation | Home
www.uawildcatresearch.org/Tucson_project.html ▼
The University of Arizona Wild Cat Research and Conservation Unit works to ... Genetic structuring,

gene flow, and taxonomy of northern jaguars (M. Culver)

A Picture Of The Only Known Wild Jaguar In The US - Business Insider www.businessinsider.com/a-picture-of-the-only-known-wild-jaguar-i... * Business Insider * Jun 28, 2013 - Photos of the only known wild jaguar to live in the United States were ... which noted that several grainy pictures of the big cat were posted on ...

Which big cat has the strongest bite? | Discover Wildlife www.discoverwildlife.com/animals/mammals/which-big-cat-has-strongest-bite ▼ Nov 28, 2014 - BBC Wildlife section editor Sarah McPherson answers your wild ... "The strength of the jaguar's bite is due to the arrangement of its jaw muscles ...

Figure 12 "jaguar cat wild habitats" cluster



Jaguar (Panthera onca) - Animals - A-Z Animals - Animal Facts

a-z-animals com/animals/jaguar/ *
Jaguar Classification and EvolutionThe Jaguar is the largest feline on the ... The Jaguar has been severely affected by habitat loss throughout much of its ... large size and dominant nature of the Jaguar, there are no other wild animals that are ..

Similar: jaguar cat wild habitats tiger

Expand Cluster

Ultimate Family of Big Cats Lion Tiger Cheetah Jaguar (HD) EPIC



Figure 13 Depth Clustering test "jaguar cat wild habitats" clusters

Similar: jaguar cat wild habitats protecting

Collapse Cluster

Jaguar - Wikipedia, the free encyclopedia

https://en.wikipedia.org/wikii/Jaguar * Wikipedia * Jump to Distribution and habitat - The jaguar has been an American cat since crossing the Bering ... to be 16 years old, older than any known wild jaguar.

Jaguars, Jaguar Pictures, Jaguar Facts - National Geographic animals nationalgeographic com/animals/mammals/jaguar/ ▼ National Geographic Society ▼ Unlike many other cats, jaguars do not avoid water in fact, they are quite good ... Aardvark; Adélie Penguin; African Elephant, African Lion; African Wild Dog ...

After protecting habitat for jaguars, expert believes the species can ... https://www.washingtonpost.com/...habitat...jaguars.../10b2591e... • The Washington Post • Dec 22, 2014 - Hunting, the loss of habitat and hunting of the jaguar's prey. It's down to 50 percent ... Jaguars are doing better than the other big cats elsewhere because they had a respite. During the ... How many jaguars are left in the wild?

Jaguar - Center for Biological Diversity

Saguar - Center for Biological Diversity
www.biologicaldiversity org/species/mammals/jaguar/ ▼ Center for Biological Diversity ▼
The jaguar is the largest cat in the Western hemisphere. ... The only known wild jaguar in the United
States lives just outside Tucson, Ariz. ... times sued the U.S. Fish and Wildlife Service to obtain a recovery plan and critical habitat designation.

The Jaguar Project :: Habitat Loss Prevention and Wild Cat ... www.thejaguarproject.com/ *
THE JAGUAR ACCESS GATEWAY PROJECT is working to establish long-term conservation measures to protect the habitat of the jaguar and the five other felid

Jaguar , Costa Rica - information, where to see it, and photos www.anywherecostarica.com/flora-fauna/mammal/jaguar ▼ Habitat Currently in Costa Rica, this cat is found almost only in forests of protected reserves. Range In suitable habitats, it lives from northern Mexico to northern

Jaguar | Species | WWF www.worldwildlife.org/species/jaguar ▼ World Wide Fund for Nature ▼ Learn about the jaguar, as well as the threats it faces, what WWF is doing to ... due to deforestation continue to threaten the survival of these marvelous cats. ... In Peru, WWF continues to track jaguars to learn more about their habitat requirements. ... Saola; Orangutan; African Wild Dog; Cross River Gorilla; Mountain Gorilla ...

Feds Protect Habitat for Jaguars in the United States - WildEarth

www.wildearthguardians.org/site/News27page=NewsArticle... * WildEarth Guardians * Mar 5, 2014 - WildEarth Guardians protects and restores the wildlife, wild places, wild rivers, and health of the American West. ... Feds Protect Habitat for Jaguars in the United States. Areas are Key to Reestablishing Rare Cats in the U.S.

Elusive wild jaguars, cubs photographed - Technology & science ... www.nbcnews.com/.../elusive-wild-jaguars-cubs-photographed-colom... ▼ NBCNews.com ▼ Jun 6, 2012 - For the first time, cameras have documented wild jaguars with cubs in an oil ... hope to

Figure 14 "jaguar cat wild habitats protecting" cluster

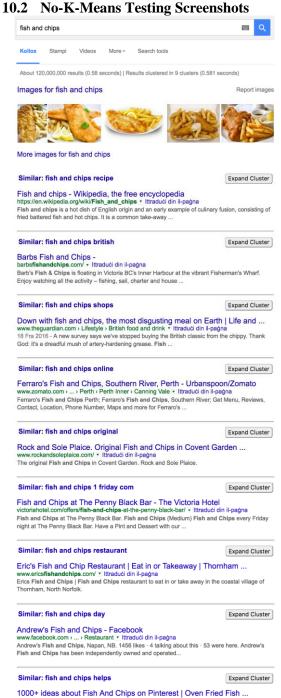


Figure 15 Clustering of results for "fish and chips" using No-K-Means.

https://www.pinterest.com/explore/fish-and-chips/ >
Discover thousands of images about Fish And Chips on Pinterest, a visual bookmarking tool that helps you discover and save creative ideas. | See more about ...

Similar: fish and chips restaurant

Collapse Cluster

Eric's Fish and Chip Restaurant | Eat in or Takeaway | Thornham ...

www.ericsfishandchips.com/ * Ittraduci din il-pagna
Erics Fish and Chips | Fish and Chips restaurant to eat in or take away in the coastal village of Thornham, North Norfolk.

Easy Catch Fish And Chips | Delicious Fish & Chips in Mid-Town ...

easycatchfishandchips.com/ * Ittraduci din il-pagna
Easy Catch Fish and Chips is a family run fish and chips restaurant in midtown Toronto. 1446 Yonge

Thistle Fish And Chips - Fish And Chip Restaurant In Burlington, Ontario

www.thistlefishandchips.com/ * Ittraduci din il-pagna
For traditional British fare, come to Thistle Fish & Chips in Burlington for authentic flavours, served hot!

Tom's Fish & Chips - Cannon Beach Restaurant

tomscannonbeach.com/ * Ittraduci din il-pagna
Tom's Fish & Chips is Cannon Beach's newest restaurant serving burgers and fries, fish baskets, salads and chowder!

Chatham Fish and Chips, Seafood Restaurant and Takeout Seafood

chatham**fishandchips.**com/ ▼ litraduci din il-paġna
Chatham Fish & Chips is a family owned and operated casual seafood restaurant. with indoor and
outdoor seating. Chatham Fish and Chips will take your ...

Best Fish and Chips in London | Travel + Leisure

www.travelandleisure.com > Local Experts > London * Ittradući din il-pagna

Popples. A popular take on fish and chips with locations in trendy Spitali won the 2014 Best Independent Fish and Chips Restaurant ... lds and Camden, Poppies

Cassoni's Fish and Chips - Home

cassoni.weebly.com/ * Ittraduci din II-pagna CASSONI'S RESTAURANT AND TAKEWAY 97 Stand Road Bray Co Wicklow Telephone: 01 2863270. Email: wanawan@hotmail.co.uk. Established in 1949 ...

Ocean Fish and Chips, Sacramento CA, Lunch, Dinner, Restaurant

www.oceanfishandchips.net/ * Ittraduci din il-pagna
Ocean Fish and Chips, Sacramento CA, Lunch, Dinner, Restaurant, London Style, 10 yrs experience.
Teriyaki Bowl or plate, hamburger, seafood, coupon, 50% ...

Fish and Chips in London - Things To Do - visitlondon.com

www.visitlondon.com > ... > Food and Drink > Restaurants ▼ Ittradući din il-pagna Many restaurants serve up traditional fish and chips, but which ones do this famous British dish justice?

Ocean Fish and Chips, Sacramento CA, Lunch, Dinner, Restaurant www.oceanfishandchips.net/ * Ittradući din il-paġna
Ocean Fish and Chips, Sacramento CA, Lunch, Dinner, Restaurant, London Style, 10 yrs experience. Teriyaki Bowl or plate, hamburger, seafood, coupon, 50% ...

Fish and Chips in London - Things To Do - visitlondon.com

www.visitlondon.com > ... > Food and Drink > Restaurants * Ittraduci din il-pagna Many restaurants serve up traditional fish and chips, but which ones do this famous British dish

Fish and Chips on the Beach | VisitEngland

https://www.visitengland.com/experience/fish-and-chips-beach Tttradući din il-pagna Make it a traditional English seaside holiday and have fish and chips on Mablethorpe Beach

Whitehead's Fish & Chips, Hornsea, East Yorkshire whiteheadsfishandchips.com/ * Ittraduĉi din il-paĝna

ay on the East Yorkshire Coast 6 The

Enjoy the finest Fish and Chip Restaurant and Takea Greenway, Trinity Road, Hornsea, Near Hull, East You vay, Trinity Road, Hornsea, Near Hull, East Yorkshire

Fish And Chips Restaurants in New York City | Find the Best Fish And ...

https://www.zagat.com/c/new-york.../fish-and-chips-restaurants v Ittraduci din il-pagna Discover the best Fish And Chips restaurants in New York City with reliable reviews. Get access to menus, prices, and customer ratings from Zagat today!

Figure 16 Expansion of cluster with similar search phrase "fish and chips restaurant".

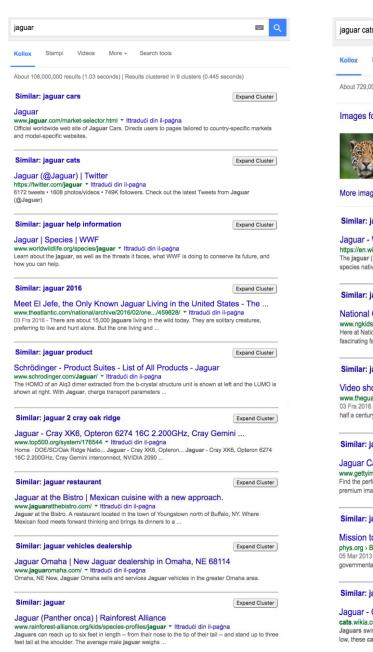
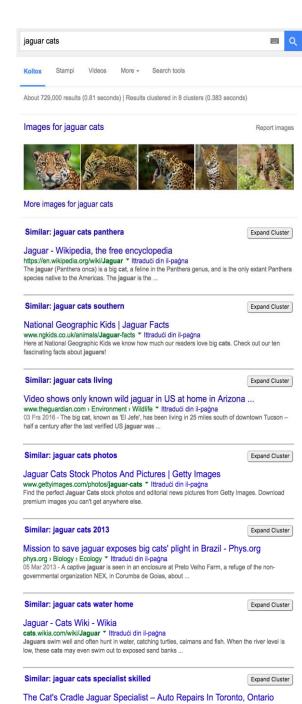


Figure 17 Clustering of search term "jaguar" using No-K-Means.



The Cat's Cradie Jaguar Specialist is your team of trusted mechanics who are skilled at repairing

Jaguars in Toronto, Ontario. Call us today for quality service

Similar: jaquar cats

Expand Cluster

Jaquar I Facebook

https://www.facebook.com/Jaguar/videos/10152812292330880/ * Ittraduċi din il-paġna A new plan needs a new boss. Unleash the cats. Discover the new #XE here: http ://www.jaguar.com/new-jaguar-xe.

Figure 18 Clustering of search phrase "jaguar cats" using No-K-Means.

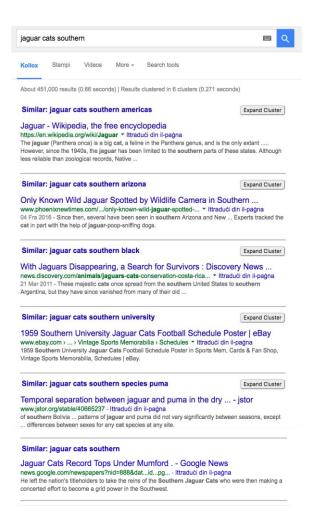


Figure 19 Clustering of results for "jaguar cats southern" using No-K-Means.

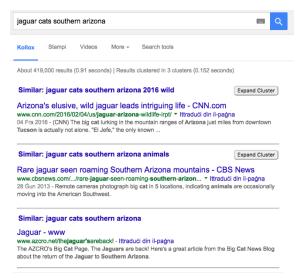


Figure 20 Clustering of results for "jaguar cats southern arizona" using No-K-Means.



Figure 21 Clustering of results for "jaguar cats southern arizona 2016 wild" using No-K-Means.

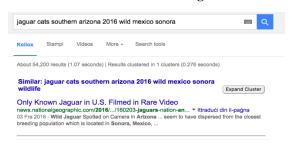


Figure 22 Clustering of results for "jaguar cats southern arizona 2016 wild mexico sonora" using No-K-Means.

10.3 Self-Organising Map Testing **Screenshots**

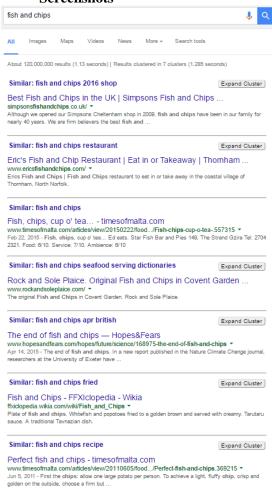


Figure 23 Collapsed clusters for "fish and chips", using SOM.

Similar: fish and chips restaurant

Collapse Cluster

Eric's Fish and Chip Restaurant | Eat in or Takeaway | Thomham ...

vvv.ericsfishandchips.com/ ▼ rics Fish and Chips | Fish and Chips restaurant to eat in or take away in the coastal village of nornham, North Norfolk.

London Fish And Chips » Dining, Fast Food » Dine » The Dubai Mall



Whitehead's Fish & Chips, Homsea, East Yorkshire

whiteheadSfishandChips.com/ *
Erjoy the finest Fish and Chip Restaurant and Takeaway on the East Yorkshire Coast, 6 The Greenway,
Trinity Road, Hornsea, Near Hull, East Yorkshire.

Thistle Fish And Chips - Delicious Restaurant Menu In Burlington ..

www.thistdefishandchips.com/Menu.aspx. *
Thistle Fish and Chips offers a delicious dine in and takeout menu in Burlington, Ontario. We serve up traditional British style fish and chips at our restaurant.

The Village Fish & Chips Petts Wood

Award Winning, Fish and Chips in Pettswood, Restaurant and Takeaway.

Easy Catch Fish And Chips | Delicious Fish & Chips in Mid-Town .

easycatchfishandchips.com/ ▼
Easy Catch Fish and Chips is a family run fish and chips restaurant in midtown Toronto. 1446 Yonge

Tom's Fish & Chips - Cannon Beach Restaurant



tomscannonbeach.com/
Tom's Fish & Chips is Canno baskets, salads and chowderl Tom's Fish & Chips is Cannon Beach's newest restaurant serving burgers and fries, fish

Get certified! Fish and chip shops — Marine Stewardship Council

https://www.msc.org/chippies *
Show oustomers how seriously you take sustainable fish sourcing by using the MSC ecolabel on menus in your restaurant or take-away.

Chatham Fish and Chips, Seafood Restaurant and Takeout Seafood

chathamfishandchips.com/ *
Chathamfishandchips.com/ *
Chatham Fish & Chips is a family owned and operated casual seafood restaurant. with indoor and outdoor seating. Chatham Fish and Chips will take your ...

Cassoni's Fish and Chips - Home



cassoni.weebly.com/ ▼
CASSONI'S RESTAURANT AND TAKEWAY 97 Stand Road Bray Co Wicklow Telephone: 01 2863270. Email: wanawan@hot

Figure 24 Top 10 results in the expanded cluster "fish and chips restaurant".

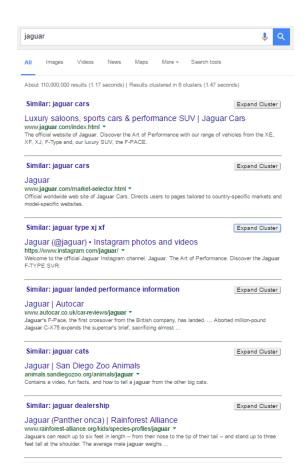


Figure 25 Collapsed clusters for "jaguar" using SOM.

Similar: jaguar cats Collapse Cluster

Jaguar | San Diego Zoo Animals

animals.sandiegozoo.org/animals/jaguar ▼
Contains a video, fun facts, and how to tell a jaguar from the other big cats.

Jaguar (Panthera onca) - Animals - A-Z Animals - Animal Facts ..

a-z-animals.com/animals/jaguar/ * Jaguar Classification and EvolutionThe Jaguar is the largest feline on the American continent, and is the only one of the world's 'big' casts to be found in the New ...

Jaguar | Panthera

JdQUati | Fartitieral | https://www.panthera.org/cat/jaguar * | The jaguar is the largest wild cat in the Western Hemisphere. Although jaguar populations are abundant in some areas, many are threatened by illegal hunting, ...

Jaguar - National Geographic Kids

kids.nationalgeographic.com/animals/jaguar/

Jaguars are the largest of South America's big cats and the third largest cats in the world. Their fur is usually tan or orange with black spots, called "rosettes" ...

Jaguar | WWF

Jadjual | VVVVP wvf.panda.org > Our Earth > Teachers > Top 10 Lists > What made the Top 10? ▼ What The Jaguar (Parthers once) is the only member of the parthers family to be found in the Americas and is by far the biggest cat on the continent.

Jacksonville Jaguars, Official Site of the Jacksonville Jaguars

www.jaguars.com/ +
The official team site with scores, news items, game schedule, and roster.

Jaguar Facts | Big Cat Rescue

Jaguar Facts | Dig Cat Rescue bigcatrescue.org/jaguar-facts/ ▼ Jul 27, 2015 - Jaguar: Parthers oncs. Common Name: Jaguar Kingdom: Animalia Phylum: Chordsta (Vertebrata) Class: Mammalia Order: Carnivora

Jaguar | Definition of Jaguar by Merriam-Webster

www.meriam-webster.com/dictionary/jaguar */
noun jag uar 'ja-gwit-gya-witr.-gwar, dal-gwit(-a)r, especially British 'ja-gya-war'. Simple Definition of jaguar.: a large, brown, wild cat with black spots ...

Video Review: Jaguar's XE S is a big cat that knows how to boogle www.gizmag.com/jaguar.xe-sv6-review/42671/ ~ Apr 7, 2016 - The Jaguar XE S combines a balanced chassis with a powerful, raspy engine to create a sports sedan sweet sport (Credit: Scott Collie/Gizmag).

Panthera onca (Jaguar) - IUCN Red List

www.iucnredlist.org/details/15953/0 *
Rather, variation is clinal - the greatest differences are found between Jaguars at the latitudinal extremes of their range. While not elevating the regional ...

Figure 26 Top 10 results in the expanded cluster "jaguar cats".



Figure 27 Clustering of results using SOM for the search "jaguar cats".