University of Bergen

Master Thesis

Optimal Compact Trie Clustering - A genetic approach

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in the

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"Quote comes here"

Quote Author

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Abstract

Faculty of Social Sciences

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Masters degree

Optimal Compact Trie Clustering - A genetic approach

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Abstract comes here

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Nomenclature

CTC	Compact Trie Clustering
GA	Genetic Algorithm

Chapter 1

Introduction

Information Retrieval is a field in information, informatics and computer science that revolves around retrieving and classifying information in order to make information more accessible. Theories and practices developed in this field drives many of the information retrieval systems we use in our every day lives such as Google Search, TinEye (an image search engine), and many more. One major area of information retrieval is classification and grouping (or clustering) of text documents or other information artifacts. Clustering will be the subject of this master thesis.

This master thesis started as a master thesis proposal by my supervisor Richard Elling Moe . The proposal suggested that work be put into optimizing the Suffix Tree Clustering algorithm. The Suffix Tree Clustering algorithm was presented by Zamir and Etzioni (1998) in the paper "Web document clustering: a feasibility demonstration." The algorithm is a clustering algorithm which extracts phrases from text documents and finds clusters by inserting these phrases into a suffix tree. Richard Elling Moe has worked with the Suffix Tree Clustering algorithm in relation to a research project at the Department of Information Science and Media Studies. The project is described in the paper "Resirkulering av nyheter I nettavisene 1999 – 2009," (Elgesem, 2009).

In this work he experimented with the Suffix Tree Clustering algorithm and implemented the Compact Trie Clustering algorithm which does not limit itself to suffixes. The original Suffix Tree Clustering algorithm proposed by Zamir and Etzioni (1998) is demonstrated in use on search engine results and showed good results. In his work with the Klimauken corpus, a corpus comprising articles from several big Norwegian newspapers, Richard

Elling Moe found that the Suffix Tree Clustering algorithm yielded poorer results. This can be explained as search engine results have been pre-filtered by the search engine. The Klimauken documents are quite varied in content and as such the default implementation and parameters of the Suffix Tree Clustering algorithm was not sufficient to get good results. This is the background for this master thesis were an approach to finding a near optimal parameter set for a specific corpus will be explored.

1.1 Motivation

1.1.1 Academic motivations

The Suffix Tree Clustering algorithm has some benefits over many of the traditional clustering algorithms. It is computationally fast having a $O(n)$ computation time where n is the number of documents. It is also phrase based which means it takes into account the position of words when comparing the similarity of documents. Traditional clustering algorithms often use the bag of words model where each document is only a set of words with positional data disregarded. The drawback is however that the Suffix Tree Clustering algorithm has shown poor performance on unfiltered text corpora. It is of interest to see if the algorithms performance can be improved. There are evidence to suggest that changing parameters for the algorithm might improve results. This master will propose an automated way in which to find better optimized parameter sets for different corpora. This method of improvement could benefit researchers who use the algorithm as part of their work to identify text clusters.

1.1.2 Other motivations

I had previously taken two courses about information retrieval and web intelligence. This area of research is very interesting and this master thesis provided an opportunity to learn more about it. I also wanted to use previous knowledge in my master thesis, so I proposed to use the Genetic Algorithm to identify good parameter sets as genetic algorithms are well suited to the task of exploring large feature spaces. I also got the opportunity to learn a new programming language, Python, as this was already used by Richard Elling Moe .

1.2 Research question

The main research question of this thesis is:

"What are the optimal parameter values for Compact Trie Clustering with regard to the news corpus?"

The main goal of this master thesis is to identify an optimized parameter set for the Compact Trie Clustering algorithm. The number of possible parameter sets are extremely big, so there is no realistic way to computationally prove that the most optimal parameter set has been found. Instead the thesis will identify an optimized parameter set that is significantly better than the default, and an approach to finding such optimized parameter sets. An experiment will be performed to verify the results.

The thesis has two subsidiary goals:

- Develop a method for determining optimal parameters for the Compact Trie Clustering algorithm.
- Apply the method to determine recommended parameter values for news documents.

This thesis is for researchers and users of the Suffix Tree Clustering algorithm. With the optimization approach discussed in this thesis they will be able to find better parameter sets for their corpora. The thesis is also very much aimed at the research group working with the project discussed in “Resirkulering av nyheter I nettavisene 1999 – 2009” and other information retrieval researchers.

This research is performed as part of a master thesis. As such certain temporal and economic constraints are imposed upon the scope and detail of the research. There was not enough time to test more than two different corpora. I also opted to only use corpora that were free of charge as this would negate the need for funds. The tests were run on personal machines which made time efficiency comparisons between parameter sets difficult.

Chapter 2

Theory

In this chapter the thesis will introduce the basic concept of clustering underpinning all clustering methods. It will formally define clustering and explain how the Suffix Tree Clustering algorithm fit into this definition. It will then move onto explaining the Suffix Tree Clustering algorithm itself and the different stages of which it is comprised. It is in these sections that the parameters to be optimzed will be explained. The theory chapter will also go into some detail about the Compact Trie Clustering algorithm, a slightly modified version of the original Suffix Tree Clustering algorithm. An investigation into performance measures used in information retrieval in general and clustering in particular will provide a foundation for how one can test the Suffix Tree Clustering and Compact Trie Clustering algorithms. The section will also go shortly into two performance measurements suitable for Compact Trie Clustering . The chapter will also provide a short section about different corpora available for information retrieval research.

In my thesis work a genetic approach to optimization of the parameters was tested. The theory chapter will therefore provide a section about the Genetic Algorithm and how it can be used to optimize parameters.

2.1 Clustering and information retrieval

Baeza-Yates and Ribeiro-Neto defines text clustering as, "*[...]given a collection D of documents, a text clustering method automatically separates these documents into K*

clusters according to some predefined criteria". The variable K here refers to the number of clusters produced by the clustering algorithm given a document set. The variable D refers to the document set comprising the documents to be clustered. Given a size N of the document set D a clustering algorithm might produce a cluster set where $K \in \{1, .., N * N\}$. In other words, a clustering algorithm might produce anywhere from a single cluster to as many clusters as there are document combinations.

The K variable can either be pre-determined and given to the clustering algorithm as a variable as is the case with K-Means Clustering. In other algorithms the K variable is undefined and varies according to different criteria such as the document collection size, the contents of the documents, the parameters given to the clustering algorithm etc.

The Suffix Tree Clustering and Compact Trie Clustering algorithms conform to this definition of clustering. Examples of other clustering algorithms that fall under this definition include the previously mentioned K-Mean algorithm and the Hierarchical Clustering algorithm.

2.1.1 Suffix Trees and Suffix Tree Clustering

The Suffix Tree Clustering algorithm was first introduced by Zamir, Etzioni, Madani, and Karp (1997) in the paper "Fast and Intuitive Clustering of Web Documents." This article discuss how suffix tree clustering can be used on search engine results to improve the results. Later an improved version of the algorithm was presented in the paper "Web document clustering: a feasibility demonstration" (Zamir & Etzioni, 1998). In this later paper Zamir and Etzioni describes the requirements for the Suffix Tree Clustering algorithm and the stages involved in Suffix Tree Clustering . They also compare the effectiveness (i.e. performance) of the algorithm compared to other clustering algorithms.

The Suffix Tree Clustering algorithm has four basic steps:

1. Document cleaning
2. Suffix tree creation
3. Base Cluster creation
4. Base Cluster merging

2.1.1.1 Document Cleaning

Document cleaning involves cleaning the strings representing each document. This is done by stemming each work, marking sentences and removing non-word tokens such as HTML tags, numbers and punctuation. The strings comprise the document snippets. Each snippet is cleaned string from the original document. There are some possible algorithmic parameters that can be identified here. For example, which parts of the documents should be extracted? Using more of the text document for snippet extraction gives the algorithm more data to work with which could yield more accurate results. There is also the question of which parts of the documents that are the best signifier of the content of that document. A nice parameter to think of here would thus be which parts of, say a news document, should be included such as titles/headings, image captions, article introductions, article contents etc. Other possible parameters that has not been investigated are possible stemming techniques (lemmatisation vs. stemming) and differing stop word lists.

2.1.1.2 Suffix Tree Creation

To make the concept of a suffix tree a bit clearer a short explanation of the trie data structure and suffixes will be provided.

The Suffix Tree Clustering algorithm use a trie data structure. INSERT TRIE DEFINITION HERE!

In context of a term $t = [c_1, ..., c_n]$ a suffix is a subterm $s = [t[m], ..., t[n]]$ where m is smaller than or equal to (in which case only one character is selected) n. To exemplify this definition the term suffix itself can be used. The suffixes of the term "suffix" are *1*) suffix; *2*) uffix; *3*) ffix; *4*) fix; *5*) ix; and *6*) x .

Zamir and Etzioni, 1998 treat documents as a collection of snippets where each snippet is a normalized sentence from that document which contains a sequence of words. The Suffix Tree Clustering algorithm extracts its suffixes from phrases (snippets) rather than single terms. A suffix in this context would thus be a defined as all the sub-phrases of a given phrase following the same rules as apply for the example above. The phrase "clustering is fun" therefore has the suffixes: *1*) clustering is fun; *2*) is fun; and *3*) fun; .

Identifying base clusters involves creating a suffix tree wherein the edges are phrases in the document collection, and nodes in the tree contain pointers to documents in the collection. Each internal node is a phrase cluster made up of all the documents that share that phrase (i.e the union of the documents in it's descendant nodes). The base clusters are scored according to the scoring function:

$$s(B) = |B| \cdot f(|P|)$$

where $|B|$ is the number of documents in the cluster B and $f(|P|)$ is a function on the length of the cluster phrase P (excluding stop words) which penalizes short phrases ($|P| < 2$), gives a linear score for regular phrases ($|P| = 2, \ldots, 6$) and a constant score to longer phrases ($|P| > 6$). Clusters with many documents and/or long phrases receive higher scores than clusters with few documents and/or short phrases. In this step it is possible to adjust two parameters. It is here possible to vary or adjust the score-threshold used by the $f(|P|)$-function. The scoring-threshold determines which words in a phrase contribute to that phrase's length. If a word is contained in just 3 or less documents or more than 40% of the documents in the collection, then that word receives a score of zero. A word will also be given a zero score if it is a stop word. By adjusting the threshold-values it is possible to influence the score of each base cluster because some phrases can become longer or shorter.

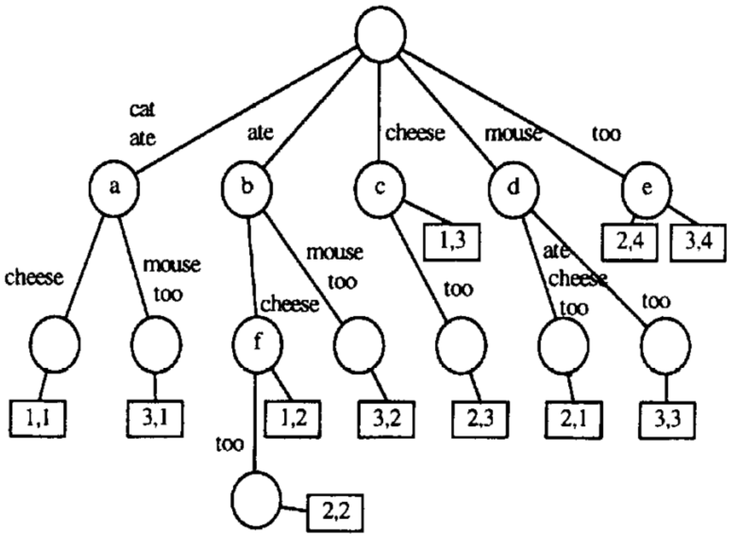

FIGURE 2.1: A suffix tree generated from the strings "cat ate cheese", "mouse ate cheese too" and "cat ate mouse too". From "Web document clustering: a feasibility demonstration" (Zamir & Etzioni, 1998, p. 48)

2.1.2 Compact Trie Clustering

What is the compact trie clustering algorithm...

2.1.3 Performance measures

What kind of performance measures are used for clustering...

2.1.4 Available corpora

Which corpora are used in clustering and/or classification research? Which ones are suited to clustering? Which ones are used in this master thesis research? Explain scope...

2.2 Genetic Algorithms

General overview of a genetic algorithm here.

2.3 Related Work

Introduce related research work in this chapter.

Chapter 3

Methodology

An introduction to the chapter.

3.1 Experimental Evaluation

Will rewrite and use the corresponding section from the project proposal.

3.1.1 Evaluation Measures

Provide info about the two forms of evaluation measures used (one from Improved suffix tree clustering article and one used by Richard). How do they work, what are the differences...

3.2 Corpora

Write a bit about the corpora used in the research (most likely just Klimauken and the reuters set). If time permits it could be feasible to use an additional news corpus.

3.3 Experimental Research

Rewrite and use corresponding section from project proposal. Try to flesh out the methodology a bit (how did I perform the testing, what where the hypotheses etc). Talk about experimental constraints and data used.

Chapter 4

Development and Testing

Chapter introduction. Describe the development process in some detail. I.e. The learning phase (learning Python and familiarizing myself with the algorithm). The second stage (modifying the algorithm slightly, refactoring). Third stage (implementing a genetic algorithm with which to test different parameter sets). Fourth stage (making a distributed version of the algorithm to make testing of larger parameter sets feasible/possible). Fifth stage (final touches on the algorithm, implementing support for converting other corpora to the snippet file format). (Sixth stage) Storing results in a database and developing a method of extracting statistical numbers. Overview of system?

Describe how the algorithm and parameters where tested. I.e. how data and results were gathered. Write about different testing stages. First stage (testing individual parameter options to determine usable value ranges. Are results correct, why?). Testing of non-distributed genetic algorithm (does the small test-case give indication of viability?). Testing distributed algorithm (larger parameter sets tested show better results?). Final testing (testing hypotheses, include two corpora?).

4.1 Stages of development

This section will outline the main sequence in which work on was done. The overview of the iterations will explain when the initial development of the different parts were started to give an short explanation of the development process.

4.1.1 Learning stage

Familiarize with algorithm ...

4.1.2 Modification of algorithm

Modified so and so ...

4.1.3 Genetic algorithm

Explain how and why it was developed as it was ...

4.1.4 Distribution of genetic algorithm

Why distribute? How? Possible problems...

4.1.5 Results storage and corpus processing

Storing results, tracking top chromosomes over generations, extracting averages for graphs etc.

4.1.6 Overview of the completed system

Give a short overview of the system ...

4.2 Testing

Give overview of testing process

4.2.1 Value Range Tests

Describe tests to discover reasonable parameter ranges ...

4.2.2 Genetic Algorithm Test

Describe first test with about 200 individuals and 50 generations.

4.2.3 Distributed Genetic Algorithm Test

Describe distributed test with more individuals and more generations

4.2.4 Final testing

Describe final test and how it answers resesearch question

Chapter 5

Analysis and Discussion

Chapter introduction. Should here provide some information about which parts of the work are going to be discussed. Should talk about the test results and how they correspond to the hypotheses. I.e. Does the testing reveal that a better parameter set has been found than the default one. Does this parameter set perform better than the default in different corpora? (Should perhaps test on two additional corpora?). This chapter should also investigate wether the test results are statistically significant (can I say yes or no on the null hypotheses?). Give definitive or estimated answer pending test results.

5.1 Results

Summarize and discuss results.

5.2 Validity and relevance

Show that data gathered are both valid and relevant. I.e. is the method of research rigorous and correct (methods of data gathering and testing). And does the data answer the hypotheses. Also discuss the statistical significance of the data in relation to hypotheses.

5.2.1 Data autenticity

Discuss how the validity of data should not be an issue even though the algorithm is distributed. (I.e. results from clients are validated). Algorithm deterministic...

5.2.2 Effects of two different measurements

Discuss how the varying measurements might affect the results... Does using one measurement over the other invalidate results? Should both be used (one to measure single category documents, the other to measure multiple category documents)?

Chapter 6

Summary and Conclusion

Summarize motivation

Restate research question ""

6.1 Results

Summarize results

6.2 Future research

What did I not have time to use? What was out of scope for this thesis? What would I like to investigate further.

6.3 Conclusion

Final remarks

Bibliography

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