# Chapter 1

# Introduction

This chapter provides a general overview of the dissertation, including background, aims, methods, study value, and main structure of this research.

## Dissertation Background:

In the era of rapid development of the Internet and smartphones, searching restaurants or specific food has become easier. For example, with Google Maps, customers could find the type of restaurant or food they are interested in more simply and more accurately. At the same time, restaurant operators can use these techniques to better expand their business [4]. On discovering this business opportunity, an increasing number of restaurant operators are advertising the link to their menu on some information applications and websites, such as Google Maps and TripAdvisor [5]. This has resulted in a large amount of data about restaurant information such as menu and restaurant description, being publicly available in a digital form. In terms of ordinary diners, the content in restaurants’ websites can only provide them with a reference for catering. However, in the eyes of data workers, a lot of potential valuable information can be mined from these restaurants’ data. That means some valuable findings such as regional differences in a country or region can be found if using data mining techniques [2] on restaurants’ websites.

## Research Aim and Research Focus:

The aim of this dissertation is to mine menu data from the “Fish&Chips” shops, revealing regional differences in the UK based on the geographical distribution of the content of the menu data. dissertation ‘Fish & Chips’ is one of the most famous foods in the UK and there are more than 1,000 ‘Fish & Chip’ shops in this country [3]. To achieve the project aim we will obtain the raw HTML data from the websites of some of these ‘Fish & Chip’ shops, and then employ data cleaning, mining, and visualisation techniques to find the content associated with particular regions.

## Research Methods:

In terms of data crawling, the dissertation will illustrate the selection of data sources and methods for crawling data from ‘Fish & Chip’ shops’ websites in the UK. The data cleaning procedure focuses on extracting and cleaning text content which is used for exploring regionality from the website HTML content, such as single independent words, noun phrases, and word pairs. The methods used for extracting and cleaning HTML content is the combination of Regular Expressions, HTMLParser and Natural Language Processing (NLP) (will be detailed in 2.2). Considering the data mining procedure of the research, data visualization technologies will be applied to mine the regional features based on the geographical distribution of the extracted content. In terms of the classification (regional content and national content) of the extracted datasets, the project employs machine learning methods, such as decision trees and regression classifiers (will be detailed in 2.4) to generate the regionality result. Specifically, this research is an iterative process and includes four rounds of evaluation and improvement (showed by Figure. 1) since the entire study is an exploratory process that there are no existing criteria to verify the rationality of the method selection and the correctness of the results. In fact, the features that could be used for reflecting regionality of the text is unknown and the evaluation of regionality content is based on the evaluator’s experiences to some extent. For example, the evaluator knows the ‘irn-bru’ is a Scottish drink, so when this phrase is judged to be regional, the evaluator can say the decision is correct. Therefore, regional features and regional results are derived from each iteration, including exploration, evaluations, and improvements. In each iteration, the project may use or update the methods in the previous iteration. Besides, each iteration will also evaluate the results to identify problems and propose improvements for the next iteration.

## Value of the Research:

The research links seemingly unrelated menu information to regional differences of the UK through exploring regional content from the messy menu dataset. In addition, some features of regional content in terms of the geographical distribution are discovered. Furthermore, the methods and algorithms used in this project are universal, and they can also be used to find regional differences in other countries or used in similar studies.

## 1.5 Structure of the Dissertation

The structure of this dissertation is organised as follows: Chapter 2 covers background knowledge, which mainly illustrates the main techniques and algorithms used in this research. Chapter 3, Chapter 4, Chapter 5 and Chapter 6 are all related to methodologies, findings, evaluations, and improvements, which composes the four iterations of the project. Chapter 3 describes the first iteration, presenting the procedures of obtaining regional results of single independent word by one kind of feature. Chapter 4 is related to the second iteration, which describes the application of decision tree to get regional results of the single word. This chapter uses two types of decision tree algorithms and the makes comparison between the two algorithms. Chapter 5 covers the third round iteration, which introduces the logistics regression to obtain the probability that the single independent word is judged as a regional word. This chapter focuses on evaluating the importance of the selected features and the threshold regarding probability, in order to identify the number of probabilities exceeds the threshold, which would be judged as regional word. Chapter 6 is about the fourth iteration, which demonstrates the results of using the other two kinds of datasets (noun phrases and word pairs). Chapter 7 is a conclusion about this research. Chapter 8 provides a description of the improvement could be included in future work and also introduces the limitations, and recommendations.

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# Chapter 2

# Background

This chapter focuses on describing the techniques and methods used in the dissertation. Section 2.1 gives the statement of selecting data source and the definition of the web crawling. Section 2.2 presents an overview of data cleaning procedure and data cleaning techniques used in the project. Section 2.3 provides the description of core algorithm and techniques used for geographic data visualisation. Section 2.4 aims to illustrate the data mining process in the project and some machine learning methods used for classifying regional content.

## Web crawling

Before crawling data from websites of ‘Fish & Chips’ shops, the dissertation selected data sources that included food delivery websites such as Just-Eat [3] and independent ‘Fish & Chips’ shops’ websites. The advantages of using food delivery websites as data source is that it is convenient to search ‘Fish & Chips’ shops in each city of the UK by postcode. In addition, each shop which is searched out is available to crawl data directly. Whereas when searching on independent websites it may be the case that the desired content (eg menu) is only available in a PDF and hence cannot be crawled. Further on independent websites it may be the case that the URLs provide on the site are broken and hence also cannot be crawled. Thus, the dissertation originally planned to use the food delivery website as a data source. However, sites like Just-Eat clearly state that direct crawling of their web site data is not allowed. Therefore, using such a food delivery website to crawl data directly in this dissertation project may be illegal. This fatal flaw meant this method could not be used. As a consequence, Google Maps has been used to find independent websites of ‘Fish & Chips’ shops and the data from these independent websites has then been used as the data source.

Web crawling is the mechanism by which information has been collected from target websites [1]. Specifically, the Python module urllib2 has been used to simulate browser behaviour to download web pages and handle request errors [2] to get the full website HTML data of ‘Fish & Chips’ shops.

## HTML data cleaning techniques :

Data cleaning is used for improving the quality of data which is used as data for subsequent data processing through detecting inconsistencies and removing errors [4]. In this project, the dataset required to be cleaned is HTML data. The goal of data cleaning in this project is to obtain independent words (such as ‘haggis’), noun phrases (such as ‘monday supper deal haggis’) and word pairs (such as ‘salad with haggis’ can be divided into ‘salad with’ and ‘with haggis’ word pairs) with shop coordinates from HTML datasets and city dataset which contains coordinates.

In the web-based dataset, there is a lot of content that is not required by this project, such as name, attributes of HTML tags, script code and special symbols. The project only focuses on information which the user can see on the page rather than the implementation details of the page. However, in terms of content which customers can see, there is a lot of redundancy, such as the singular and plural of the same noun all represent the same word. Therefore, the project should not only filter useless content in the HTML data, but also classifying words that represent the same meaning such as ‘chip’ and ‘chips’ into the same category (mainly focuses on the classification of singular and plural nouns with the same meaning). Fortunately, the regular expression, HTMLParser and NLP can help the project to achieve the data cleaning goal.

## HTMLParser

HTMLParser is an open source, fast and robust HTML parsing tool for extracting and cleaning content of HTML [5, 6]. It can customize HTML tag content extraction based on user requirements [7]. In this project, in this project, the HTMLParser mainly plays the role of data extraction and filtering. Since the data source used in the project is an independent website, the HTML structure of most websites is different (small parts of the website structure are the same because they are developed by the same company). Therefore, HTMLParser plays a huge effect that it does not pay attention to the structure of the website design, only pay attention to the name of the HTML tag, such as ‘div’ and ‘script’. As a consequence, the project can easily filter absolutely useless content based on the tag name, such as the content in the "script" tag and extract potentially valuable content from the remaining tags. However, because the design styles of different web pages are different, the extracted data may also contain special symbols such as field trailing space symbol that will interfere with the cleaning result. Thus, the project also uses the regular expression which is a source language which can locate specific character strings in text [8] to filter the result of the HTMLParser.

## Natural Language Processing (NLP)

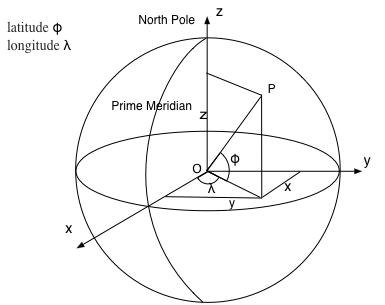
In order to solve the problem of data redundancy in the extracted content, the project uses method of semantic recognition in NLP. Natural Language Processing (NLP) is a research about using computer to understand and manipulate natural text or speech to process tasks [9]. This project mainly wants to change the singular and plural nouns of the same root into singular nouns and the Natural Language Toolkit (nltk) can provide the solution. nltk is an open source tool written by Python with collection of modules and corpora [10, 11]. nltk determines the part of speech of a word based on its corpus and the identification method has been encapsulated which the project can use directly to identify plural nouns and convert them to singular forms.

## Geographic data visualisation:

One of the targets of the project is to explore geographically distributed features to represent regionality, so the project uses Cartesian coordinate systems for geolocation calculations and Matplotlib for data visualisation.

## Central point calculation algorithm

The core calculation in this project is the coordinates of the central point which is the centre of all shops which contain a specific content. The importance of the central point is that most regional features found in this project are derived from it. The project uses a set of geographic coordinates containing this content to calculate the centroid. The algorithm used in this project for calculating the center point through combining geographical coordinate system with Cartesian coordinate systems which regards the Earth as a sphere (Fig.2). This combination is also known as ECEF ("earth-centered, earth-fixed") [12]. In Cartesian coordinates, earth is a sphere centered at the origin [13]. The z axis points to the north pole. The x, y axis are on the equatorial plane that the x-axis passes through the equator and the prime meridian and the y-axis points to the equator at 90 degrees east [14]. However, the coordinates of the central point obtained by using this algorithm in the project are not accurate since the algorithm regards the earth as a sphere rather than ellipse which is the shape of the earth itself. Fortunately, the requirement of the accuracy of the coordinates of the central point in this project is not high, because this project is concerned with the distribution of content.



**Figure. 2 geographical coordinate system with a cartesian coordinate systems**

As Fig.1 shows, point P in Fig. 1 represents a geographical coordinate with latitude and longitude . A series of coordinates can be represented as latitude , longitude  (i = 1n). Thus, in cartesian coordinate systems, the coordinates of the three directions can be expressed as:

= ,

= ,

= ,

The centroid of these points is the average of the sum of :

() = ,

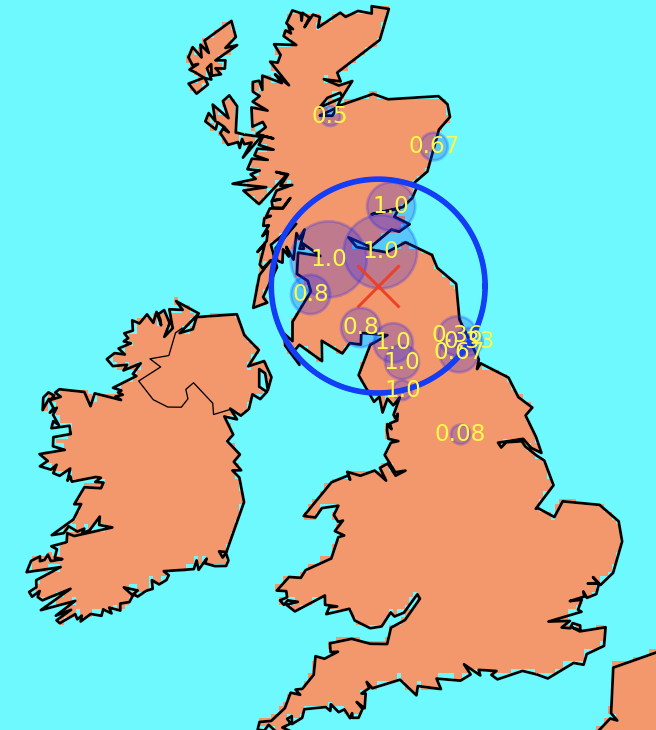
The coordinate of the centroid can be expressed as:

= ,

=

## Visualisation with Matplotlib

After the project gets the coordinates of central point and other features such as radius, the project hopes to display the distribution of a specific content on the UK map to observe the distribution of the content. The visualisation tool selected by the project is Matplotlib package of Python which is an open source portable Python plotting package used in scientific, engineering and financial fields [15]. It can implement complex data visualisation processes with simple encapsulated methods. Because of the convenience of this tool, most data visualisation processes in the project are achieved by it. Specifically, in this project, Matplotlib package mainly completes the visualising of geographic information distribution and the line graphs. In terms of the visualisation of geographic information distribution, the project uses one of the Matplotlib toolkit named Basemap [16]. Basemap provides a possibility that the project can draw Matplotlib plot over the real-world map [17]. This indicates the Basemap replaces the bottom canvas of the Matplotlib, so it can implement the goal of plotting other graphics such as radius and circumference curve on the map. The following figure (Fig. 3) is an example of using Basemap to visualise the distribution of ‘haggis’.

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**Figure 3: Haggis distribution range**

## HTML data analysis with machine learning methods:

This project is an exploratory project, therefore, at the beginning of the project, there is no clear definition of regional features. As a result, the discovery of features and obtaining regional results are the process of data mining. Data mining is a process to extract patterns which represent useful information from massive dataset [18]. In the early stage of the project, the discovery features went through two phases. The first is to find some content widely distributed on the map and some regionally distributed content based on the results of the geographical distribution of content such as Fig. 3. The second phase is to find the commonalities of these widely distributed content and regional content, and the commonalities can be regarded as the features (national or regional) of the content. For example, in the range of 200,000 meters from the central point, the number of shops which have the same regional content will be more than 70% of total shops number which contain that content. However, in terms of most national content, this number will be lower than 60%. As a consequence, in the range of 200,000 meters, the number of shops exceeding 70% of the total number can be regarded as a feature of regional content. After the project uses the above method to get more features, the project tries two machine learning methods to judge the regional content. One of them is the decision tree and other is logistic regression and both of them belong to the method of supervised learning. Supervised learning means that the training data has both features and labels. Through training, the machine can find the connection between the features and the labels by itself and can judge the labels when facing data with only features without labels [33]. In this project, the training data set includes widely distributed content and regional content that are judged in advance based on experiences, and they are all marked on zero (widely distributed) or one (regional).

## Decision Tree

Decision tree is mainly used for classification and prediction of models [19] and the project uses decision tree to classify regional content and widely distributed content. There are two algorithms used in this project. One is the ID3 algorithm and the other is the Cart algorithm. Both algorithm use training dataset to create the tree and then use the tree to classify the test dataset [20]. The reason why the project chooses these two algorithms is that after the project found some features of regional content, the thresholds of these features’ value were defined by the developer. For example, if the average distance of all shops which contain a specific content more than 300,000 meters from the central point, the content is definitely not regional content. The threshold 300,000 meters is defined by developer and can be regarded as a symbol (‘>300,000’). Thus, the project uses the ID3 algorithm which uses symbolic data to generate the decision tree [34] to classify the content to regional or not. However, after the project analyses the results of the ID3 algorithm, the project realized that the threshold of each feature may not accurate, because these thresholds are defined by the developer by observing a limited amount of data. As a consequence, the project wants to use an algorithm to define the feature threshold automatically. Fortunately, Python provides a toolkit (Sklearn) which integrates a variety of machine learning algorithms for supervisory and unsupervised problems [36]. This toolkit can help the project to achieve the goal of finding thresholds automatically.

## ID3 algorithm

ID3 algorithm constructs decision tree by selecting most useful features [35]. These features can make the classification of data set more effective. Thus, the project requires an algorithm to measure the suitability of features and select features. The Entropy can measure the impurity of training dataset [21] that the greater the entropy, the more complex the information. As a consequence, the project can use the information gain which is the amount of entropy lost by adding a feature to select representative features.

Entropy:

Information Gain: a represents a feature.

The decision tree construction process of ID3 algorithm is divided into the following steps:

1. Loading training dataset.
2. Calculating the Entropy.
3. Data segmentation based on optimal segmentation feature.
4. Selecting the best segmentation feature based on the maximum information gain.
5. Recursively building a decision tree.
6. Sample classification.

## Cart algorithm

The limitation of the ID3 algorithm that the ID3 algorithm can only deal with discrete values [22] so that the feature values must be classified based on numerical variables. Thus, the project should first observe the feature value to find the criteria and then mark each training data according to this criteria. This will not only cause the inaccurate of the thresholds but also affect the efficiency of code execution that the project should mark symbol for each feature value of each content data. As a result, the project uses the Sklearn package which uses a kind of optimised Cart algorithm [23] to generate the decision tree, including classification tree and regression tree. In this project, the classification tree is more suitable, because the target of the decision tree is binary.

Cart algorithm uses binary recursive partitioning procedure to split datasets [24]. In classification tree, Cart algorithm uses Gini index as a property to determine partitioning [25]. The Gini index indicates the uncertainty of the sample. The larger the Gini index, the greater the uncertainty of the sample set which means the probability of the sample belongs to a class is low. In terms of each feature, the Cart algorithm will traverse all possible splitting methods and select the feature which has minimum Gini index as the division criteria [26]. The following formulas shows the calculating of the Gini index.

Assuming that there is a K class, the probability that the sample point belongs to the K class is , then the Gini index is defined as:

Assuming that be the subset of samples belonging to the k class in D, then the Gini index is:

Assuming that feature A divide the sample D into two data subsets D1 and D2, then the Gini index of the sample D under the feature A is:

The steps to generate a decision tree using the Cart algorithm are as follows:

1. Using each feature A in the sample D and each possible value of A (A>=a and A<a) to divide the sample into two parts and calculate the Gini (D, A).
2. Find the optimal segmentation feature which has the minimum Gini (D, A). Next, determining whether the splitting stop condition is satisfied. If not, output the optimal segmentation point.
3. Recursive call (1) (2)

After obtaining the classification result of the decision tree, the project wants to explore the possibility of each classification result such as how likely is ‘haggis’ to be classified as regional content. However, the project cannot get the probabilities through using the decision tree. Therefore, the project wants to use a regression classifier to get the probability that a particular content is in a category.

## Logistic Regression

The project studies the classification problem, so the dependent variable of the model is classification variable (0 or 1) and the independent and dependent variables of the model are nonlinear. As a result, logistic regression model is more suitable for this project and the project selected the logistic regression model of the Sklearn package as the classifier to find the possibility that each piece of content is judged to be regional.

Logistic regression is well suited to describe the relationship which is expressed as probability between classification results and one or more classifications [27]. It can adapt to multiple classification results. In this project, logistic regression is used to calculate the probability of a binary event occurring under multiple independent features [28]. The following model is the model of logistics regression:

denotes the vector of feature variables, and denotes the associated binary output. represents the weight vector and the is the transposed matrix of w. is the sigmoid function. is the intercept. The logistic regression has model:

Logistic loss function ( is ):

Supposing the training dataset is and the average logistic loss:

Logistic regression problem:

Overfitting problem: in supervised learning when there are many input features, but only a small number of key features determine the classification target. That is, when the number of training set data is insufficient, the classification model may perform well on the training dataset but not well on the test dataset [29]. Thus, when there are many features, overfitting will become a problem of the model unless the training set is ample [30]. In order to solve this problem, L1 and L2 regularizations were used.

L1 regularization [29]:

Lasso (L1) penalty encourages the sum of the absolute values of the to be small [30]. It uses sparsity to fit model with many features [31]. The sparsity means that L1 penalty will automatically filter some features that have less impact on classification. L1 penalty achieves the filtering by reducing the regression coefficient to 0 and slightly reducing other regression coefficients [32].

L2 regularization [29]:

L2 penalty encourages the sum of the squares of the to be small [30]. It will reduce the regression coefficient but will not be zero [32]. Thus, L2 penalty will weaken the dominant classification feature and and enhance the influence of other features. If each feature has an effect on the classification, L2 penalty is more suitable.

In this project, using logistic regression and its L1 and L2 regularizations can not only help the project to obtain probabilities but also help the project to see the impact of each feature on the classification results.

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# Chapter 3

# Iteration 1

Statement: aim to know independent words distribution through map and according to the map and ratio (the number of shops whose distance is less than 20000 meters from the center point/ total shop number) to find features of regional words.

* 1. **Methodology**

Iteration one is mainly focuses on four aspects, which are web data acquisition, HTML data cleaning, geographic data and ratio trend visualisation and exploration of features.

1. **Data acquisition**

After the project identified the data source is independent ‘Fish & Chips’ shops’ websites, the project started to find URLs of these websites through searching on the Google Maps and other food recommendation websites. The initial goal of the project is to obtain a collection of shops that their distribution can cover all parts of the UK. However, in the UK, although there are a lot of ‘Fish & Chips’ shops, not every ‘Fish & Chips’ shop offers the menu website. Besides, in these shops that provide the menu page URLs, some pages are unavailable. These unavailable websites include websites that provide invalid links, websites that are being maintained, and websites that have content in PDF format which cannot be crawled. As a consequence, the project finally collected two hundred and forty available websites of the ‘Fish & Chips’ shop. The distribution of the shops which contain these websites basically covers most parts of the UK. However, although the distribution of shops covers most cities, the number of shops in each city still shows bias. That means most of the shops are concentrated in densely populated cities such as London, Manchester and Glasgow, and other cities with sparse populations such as Inverness and Carlisle have fewer shops. Thus, this imbalance will be reflected when the project visualises the shops' geographic data in 3.1.3. Each ‘Fish & Chips’ shop collected by the project will be assigned id, city name, and the URL and this information is stored in an CSV format file. Id is used to uniquely identify the shop and the city name is used to find the coordinates of the city where the shop is located. After the project completes the store collection, the project wrote a Python script that uses urllib2 module to crawl HTML data from the collected websites. The urllib2 module provides a way to simulate a browser to send HTTP requests to a website. This method avoids the problem of denying access due to detection of abnormal access set by some websites. The result of the script is multiple independent files, each of which stores the HTML source code of a shop, and the file name is the Id of the shop.

1. **Data cleaning**

Cleaning independent words (Special symbol filtering, uppercase conversion to lowercase, using NLP method to analyse part of speech to complete noun singular and plural combination).

In the iteration one, the data cleaning procedure mainly focuses on filtering useless HTML content, extracting the content in the HTML tag, splitting the content into separate independent words and classify the singular and plural of the same noun into one class. The project achieved data cleaning goal through writing a Python script. Firstly, the script sequentially reads the HTML file that the project crawls and hand it to the HTMLParser for processing. The HTMLParser firstly filters the tags with the content in them that project do not need. The useless tags names are defined by the project and in this project, useless tags are ‘script’, ‘style’, ‘link’, ‘head’, ‘a’ and ‘title’, since most of the content in these tags is HTML code. Next, the HTMLParser will sequentially recognize the names of other tags with their content, but this project only focuses on the content. In order to extract independent single words, the project uses

1. **Data visualisation**

* Mark points on the map, calculate central point of all shops, outlier points identify and filter, draw radius.
* Draw the ratio trend.
  1. **Findings:**

Find some regional words based on ratio and map.

**3.3 Evaluation:**

It is imperfect to rely solely on the ratio feature, and it requires more features. Give examples.

* 1. **Improvement:**

1. Observing the data set and according to the coordinates information to find more features, such as ‘city number’, ‘proportion’, ‘average distance’, ‘shop numbers’.
2. Decide to use decision tree to classify the words.

# Chapter 4

# Iteration 2

Around 8 pages

Statement: aim to use decision tree to classify the independent words and compare result of two decision tree algorithms

* 1. **Methodology:**

1. Generate different training sets that match the two algorithms based on the observations in iteration 1.
2. Generate two kinds of trees and visualise two trees.
   1. **Findings:**
3. Which words are judged as regional words.

(2) Differences between two algorithms.

**4.3 Evaluation:**

(1) Based on experiences.

(2) Difficulties of evaluation

* 1. **Improvement:**

1. Find HTML context of the words and analyse why these words are judged as regional words.
2. Can consider noun phrases and word pair as analyse target.
3. Can consider to use classification method in sklearn package.

# Chapter 5

# Iteration 3

Around 8 pages

Statement: aim to use noun phrases and word pairs as dataset to find regionality information in the menu. Besides, using logistic regression classifier to classify.

* 1. **Methodology:**

1. Data obtain: Decomposing the content in HTML into noun phrases and word pairs.
2. Data cleaning: Cleaning independent words (Special symbol filtering, uppercase conversion to lowercase).
3. Generate training dataset for noun phrases and word pairs.
4. Use Cart algorithm to generate decision tree and use logistic regression model to classify.
   1. **Findings:**
5. Independent words findings.
6. Noun phrases findings.
7. Word pairs findings.
8. In logistic regression, mainly describe the impact of features and the selection of features.
   1. **Evaluation:**
9. Independent words use context, compare the result between logistic classifier and the decision tree.
10. Noun phrases and word-pair can evaluate directly and compare the result between logistic classifier and the decision tree.
    1. **Improvement**

# Chapter 6

# Conclusion

1 or 2 pages

# Chapter 7

# Future work

1 or 2 pages