Can we NLP a title?

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1 Introduction

Under the context of natural language processing, this lab explores the relation between job descriptions and salaries. This topic was the focus of a Kaggle competition whose sponsor, Adzuna, had a database of job listings of which only provided half of the salary information and the compitition was to predict the salary of other half of the data (the winner recieved $3000). As applicants will more likely apply to descriptions that give a salary, Adzuna"s placement rate (and hence revenue) is improved if they can provide an estimated salary for those descriptions that did not originally include one. (The employee recruting business is structured so that Adzuna generally can"t directly ask the companies to provide salary estimates.) This is challenging from the legal standpoint, as grossly incorrect salaries may expose Adzuna to claims from applicants and companies, and applicant experience, since Adzuna"s estimates must seem plausible to applicants before they will be willing to spend the time applying.

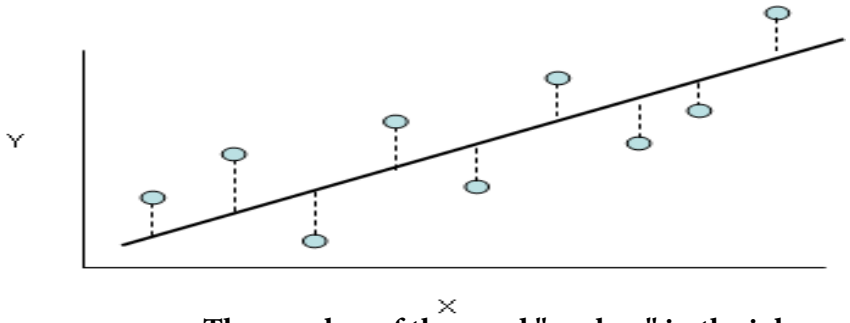
While Adzuna could manually estimate these salaries, scalability encourages throwing computers at the problem. In this lab we will be using Adzuna"s job description and salary datasets, divided into training and test sets. These descriptions vary in word count, industry, employment level, and company location, while the salaries are the mean of the provided salary range. The variability in description content leads to a notoriously sparse matrices, so we will be interested in the tradeoffs of various feature descriptors. The naieve approach to this problem is to count the occurrences of individual words and associate them to salaries; here each word is a feature and as there are many descriptive words the resulting matrices will be sparse. Other feature choices may be individual word length, occurrences of word pairs or triplets (ie "technical communication"), n-grams (sequences of n characters), and many others. Note that it is common to ignore stop words like "the","a","it","you","we", etc... because they add little information.

2 PreLab

For this lab we are going to generate the predictions based on seperating the words and the salary we have from the trainning set by a line or a hyper plane. The hyper plane is used to predict salary by checking the taking the salary of the closest point on the hyper plane to the new job description. But how should we create the hyper plane such that we get good results? One method of choosing the hyper plane is by choosing the hyper plane such that we get the predicted salary on the trainning set has the smallest Least Square (LS) error.

Least Squares errors is the error resulted from the distance between the predicted salary on the hyper plane and error and the of the predicted minimization of $||\mathbf{A}*\mathbf{x} - \mathbf{b}||_2$, Where **A** is the **NxM** word frequency matrix where **N** is the number of job descriptions and **M** the number of unique words in all of the job description, **b** is the salary of the trainning set stored in a **N** sized vector, and **x** is the prediction vector that creates the hyper plane for that predicts the salaries from the job description. The optimal x vector that creates the best hyper plane can be derived from the least square error to be $\mathbf{x\hat{}} = (\mathbf{A}^T*\mathbf{A})^{-1} * \mathbf{A}^T * \mathbf{b}$

Lets take a smalll example of the Least Square error. Lets assume that you want to predict salaries you get from a job based on only one word like "analyse" that you see on the advertisment. You might get something similar to Figure 1. The horiaontal axis represents the number of times you see the word "analyse" and the vertical axis represents the actual salary from the job. The strieght line is the prediction line that minimizes the Least Square error. You use this line to predict salaries by taking the point and droping it to the line and then read the horizontal axis to get the predicted salary. By adding more diminsions you get a plane instead of a line



The salary predicted

The number of the word "analyse" in the job description

Figure 1: Least Square error example for one word and the predicted salary

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By minimizing the Least Square error on the trainning set which has a similar word distribution to the problem we are predicting ,we can obtain a predictor that preforms pretty well. However as you will see in the warm up excercise that obtainning a trainning word description distribution that is similar to the problem word description is not easy as cetain words are only used in a few jobs that have have varying salaries. In fact in most rows in the frequency matrix A has a lot of zeros values called a sparse matrix taht makes it hard to get an accurate hyperplane. In this lab we perform methods to combat the effects of the sparse matrix on our predictions.

2 Warm-Up

Here are two examples from the dataset:

> `Engineering Systems Analyst Dorking Surrey Salary ****K Our client is located in Dorking, Surrey and are looking for Engineering Systems Analyst our client provides specialist software development Keywords Mathematical Modelling, Risk Analysis, System Modelling, Optimisation, MISER, PIONEEER Engineering Systems Analyst Dorking Surrey Salary ****K`

with a salary of $25,000 and

> `A subsea engineering company is looking for an experienced Subsea Cable Engineer who will be responsible for providing all issues related to cables. They will need someone who has at least 1015 years of subsea cable engineering experience with significant experience within offshore oil and gas industries. The qualified candidate will be responsible for developing new modelling methods for FEA and CFD. You will also be providing technical leadership to all staff therefore you must be an expert in problem solving and risk assessments. You must also be proactive and must have strong interpersonal skills. You must be a Chartered Engineer or working towards it the qualification. The company offers an extremely competitive salary, health care plan, training, professional membership sponsorship, and relocation package`

having a salary of $85,000.

We'll first apply the word count feature descriptor. We want to ignore common words as described in the introduction. Our list of common words which we will ignore are

> `"be" "at" "you" "we" "the" "and" "it" "them" "a" "these" "those" "with" "can" "for" "an" "is" "or" "of" "are" "has" "have" "in" "or" "to" "they" "he" "she" "him" "her" "also"`

and with these words ignored the first 11 frequencies are (first 11 shown alphabetically):

Description 1		Description 2	
****k	2	1015	0
analysis	0	all	1
analyst	0	assessments	2
client	1	cable	0
development	3	cables	0
dorking	0	candidate	2
engineering	0	care	2
keywords	0	cfd	3
located	0	chartered	5
looking	0	company	1
mathematical	0	competitive	1

We can collect these word counts into the matrix A, and the salaries into the vector b:

$$\boldsymbol{A} = \begin{bmatrix} 2 & 0 & 0 & 1 & 3 & 0 & 0 & 0 & 0 & 0 & 0 \cdots \\ 0 & 1 & 2 & 0 & 0 & 2 & 2 & 3 & 5 & 1 & 1 \cdots \end{bmatrix}$$

$$b = \begin{bmatrix} 2500 \\ 85000 \end{bmatrix}$$

The least-squares solution to this problem, x is:

$$\hat{x} = \begin{bmatrix} 2576.0950 \\ 2146.7459 \\ 1717.3967 \\ 1717.3967 \\ 1288.0475 \\ 1141.2192 \\ 1067.8050 \\ 1067.8050 \\ 1067.8050 \\ 858.6983 \\ \vdots \end{bmatrix} \begin{array}{l} "chartered" from [0, 6] \\ "candidate" from [0, 5] \\ "least" from [0, 4] \\ "qualification" from [0, 4] \\ "cables" from [0, 3] \\ "risk" from [2, 1] \\ "analyst" from [3, 0] \\ "keywords" from [3, 0] \\ "located" from [3, 0] \\ "all" from [0, 2] \\ \vdots \end{array}$$

For two samples, it should not be surprising that the most heavily-weighted words are unique to each description.