A CONDITIONAL RANDOM FIELD (CRF) BASED MACHINE LEARNING FRAMEWORK FOR PRODUCT REVIEW MINING

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A Conditional Random Field (CRF) Based Machine Learning Framework for Product Review Mining

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

The task of opinion mining from product reviews has been achieved by employing rule-based approaches or generative learning models such as hidden Markov models (HMMs). This paper introduced a discriminative model using linear-chain Conditional Random Fields (CRFs) that can naturally incorporate arbitrary, non-independent features of the input without conditional independence among the features or distributional assumptions of inputs. The framework firstly performs part-of-speech (POS) tagging tasks over each word in sentences of review text. The performance is evaluated based on three criteria: precision, recall and F-score. The result shows that this approach is effective for this type of natural language processing (NLP) tasks. Then the framework extracts the keywords associated with each product feature and summarizes into concise lists that are simple and intuitive for people to read.

Keywords: Conditional Random Fields (CRFs); Natural Language Processing; Text Mining; Machine Learnings

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1. INTRODUCTION

With the rapid growth of e-commerce, people are more likely to share their opinions and hands-on experiences on products or services they have purchased. This information is important for both business organizations and potential customers. Companies can make decisions on their strategies for marketing and products improvement, which Customers can make a better decision when purchasing the products or services. Unfortunately, the number of reviews has reached to more than hundreds of thousands in recent days, especially for popular products, which hence poses a challenge for a potential customer to go over all of them. Therefore, it is essential to provide coherent and concise summaries for the reviews.

To tackle this problem, researchers have explored different angles on opinion mining which aims to extract the essential information from reviews and present to the users. Previous works have mainly adopted rule-based techniques [1] and statistic methods [2]. Later, a machine learning approach based on Hidden Markov model (HMMs) was proposed and proved more effective than previous works. However, the HMMs-based methods are limited because it is difficult to model arbitrary, dependent features of the input word sequence.

To resolve the limitation, Conditional Random Field (CRFs) was introduced [3], as it is a discriminative, undirected graphical model with the potential to model overlapping and dependent features. Prior works on natual language processing (NLP) have demonstrated that CRFs outperform HMMs [4][5]. Hence, motivated by the findings, we propose a linear-chain CRF based framework to mine and extract opinions from product reviews on the web. To accomplish this goal, there are three tasks that need to be done: (1) define feature functions for CRF construction; (2) perform part-of-speech (POS) tagging for each token (word) in the review sentences based on labeled data; (3) automatically extract all the product features and their associated opinions. In the experiment, the performance of CRFs in POS tagging was evaluated based on three metrics: precision, recall and F-score. The experimental results showed high accuracy of this approach in accomplishing sequencial labeling, on top of which many other tasks such as sentiment analysis and entity identification can be done by following a similar pipeline.

The rest of this paper is organized as follows: we will review related work in Section 2, and describe the proposed framework in Section 3. Section 4 demonstrates the experiment result. Section 5 summarizes our work and present its future directions.

2. RELATED WORK

The task of opinion mining refers to the process of extracting product features and user's opinions from subjective contents, and computationally evaluates them. In order to discover a reviewer's opinions on almost every aspect that are mentioned in the text, some researchers have attempted to mine and extract opinions at the feature level. Hu and Liu [1] proposed a feature-based opinion summarization system that captures highly frequent feature words by using association rules under a statistical framework. It extracts the features of a product that reviewers have expressed their opinions on, and then generates an opinion score for each frequent feature while ignoring infrequent ones. Popescu and Etzioni [6] improved Hu and Liu's work by removing frequent noun phrases that may not be real features. Their method can identify part-of-relationship and achieve a better precision, but with a small drop in recall. The limitation of these works is that they failed to identify infrequent features effectively. For better information component extraction, sentence-level analysis is proposed in some literatures [7, 8]. Further, extracted sentences are analyzed syntactically and semantically by exploiting POS information and dependency between words [9, 10, 11]. For example, product features are generally Nouns, and opinions are Adjectives. Thus POS information based rules can be framed to analyze opinionated texts for candidate feature and opinion extraction, followed by the application of some statistical measures to identify feasible ones and discard noises [12]. In addition to information component extraction, opinion mining research requires sentiment classification of every opinion bearing word present as a part of information component. In [13], unigram model is proposed using supervised learning technique for sentiment classification. However, dictionary-based [14, 15] and corpus-based [16] approaches are widely used for this purpose. Some researches present a good mix of statistical text classification methods and machine learning approaches to develop word-level sentiment classification system [4, 14].

Jin, Ho and Srihari [17] proposed a supervised learning framework called OpinionMiner, which was a lexicalized HMMs based approach that integrates multiple important linguistic features into an automatic learning process, but came with some limitations that are inherent in HMMs. Compared to HMMs, the primary advantage of CRFs is their conditional nature, resulting in the

relaxation of the independence assumptions required by HMMs. Additionally, CRFs avoid the label bias problem, a weakness exhibited by Markov models based on directed graphical models. A CRF can be considered as a generalization of HMM (or in other words, a HMM is a particular case of CRF where constant probabilities are used to model state transitions). CRFs outperform HMMs on a number of real-world sequence labeling tasks.

The Python Natural Language Toolkit (NLTK) has incorporated many taggers in the module, including HMM, Regular Expression, Ngram, etc. for tasks such as sequential POS tagging, NER and Chunking. We further compared the performance of our proposed CRF tagger to the pre-trained baseline tagger in NLTK 3.3 [18], and it turned out the performances were quite close, given such small training and testing samples in our case. However, CRF tagger will outperform the NLTK baseline tagger with sufficiently larger training samples.

3. PROPOSED FRAMEWORK

Figure 1 shows the architectural overview of the pipeline. It can be divided into four major steps: (1) pre-processing that includes crawling raw review data and cleaning; (2) POS tagging on review data; (3) training the liner-chain CRFs model; (4) applying the model to the test set and extract opinions.

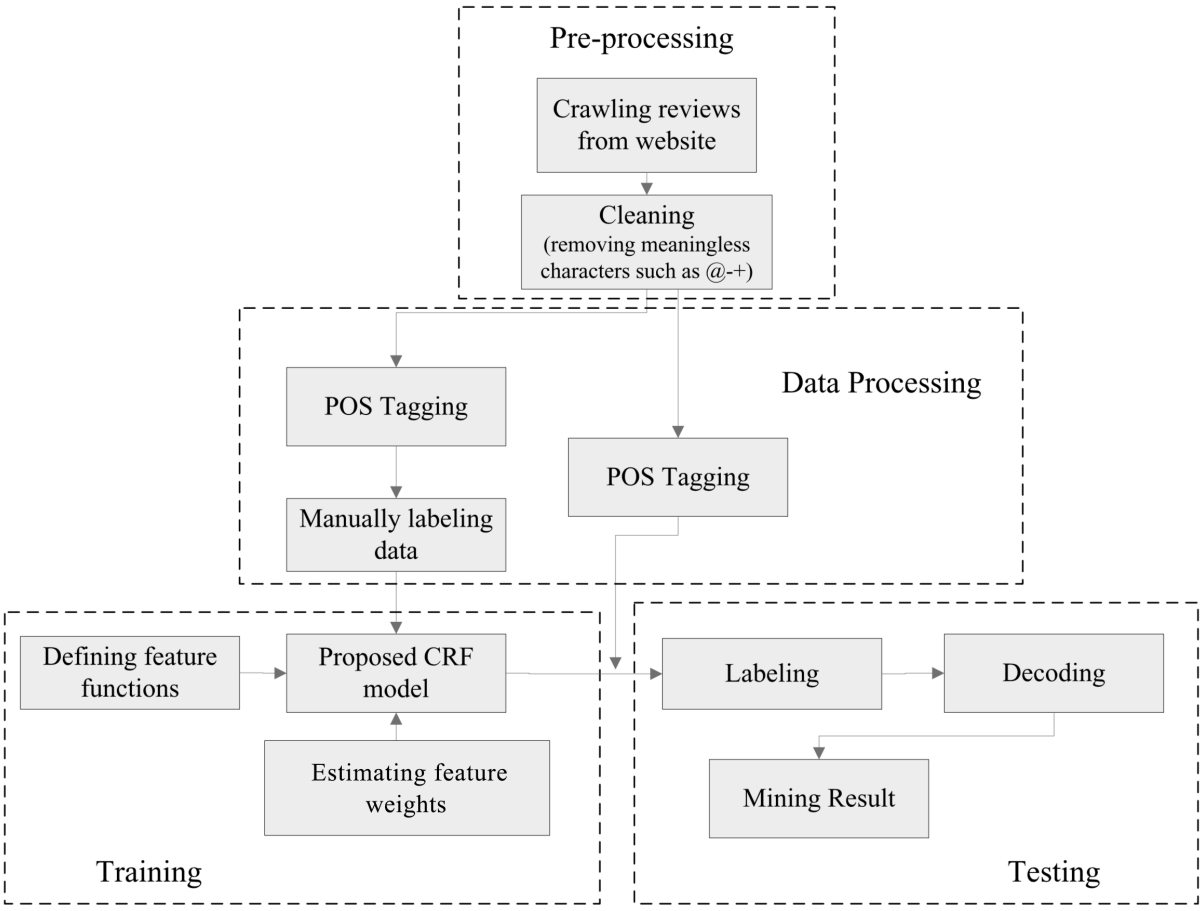

Figure 1. The Framework Pipeline

3.1. CRFs

Conditional random fields (CRFs) are conditional probability distributions on an undirected graph model [3]. To reduce the complexity, we employed linear-chain CRFs as an approximation to restrict the relationship among tags. A 1^{st} order CRF (X, Y) is specified by a vector F of local features and a corresponding weight vector λ. Each local feature is either a transition feature A_{y_{t-1},y_t} or an emission feature O_{y_t,x_t}, where y is the label sequence, x is the input sequence, and

t is the position of a token in the sequence. *Figure 2* displays the graphical sturcture of a chain CRFs, where Y forms a simple 1^{st} order chain. Here we define the 1^{st} order features:

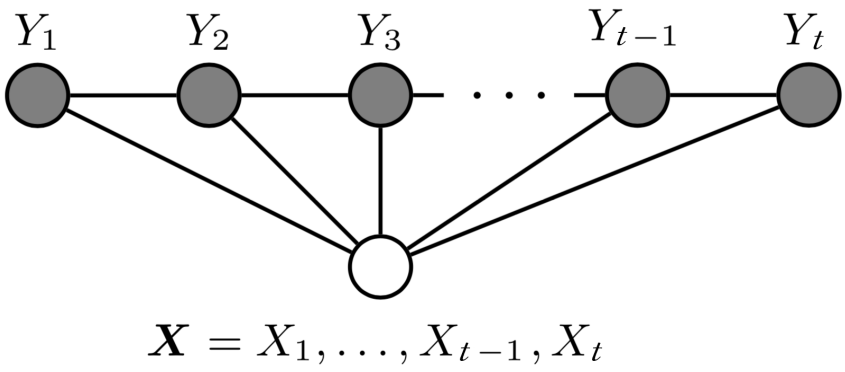

Figure 2. Graphical Structure of A Chain-Structured CRFs for Sequences

- The assigment of current tag y_t is supposed to depend on the current word x_t only. The feature function is represented as an emission feature O_{y_t,x_t} in the form $F_k(y_t|x_t) = \mathbb{1}_{\{y_t=y\}}\mathbb{1}_{\{x_t=x\}}$.
- The assignment of current y_t is supposed to depend on the previous tag y_{t-1} only. The feature function is represented as a transition feature A_{y_{t-1},y_t} in the form $F_k(y_t|y_{t-1}) = \mathbb{1}_{\{y_{t-1}=y'\}}\mathbb{1}_{\{y_t=y\}}$.

An example with the following sentence from a car review [*The seats are extremely uncomfortable*] can demonstrate how the two feature functions are incorporated. The tokenized sentence is labeled by using Penn Treebank part-of-speech Tags (see *Appendix A*) as:

The (*DT*) seats (*NNS*) are (*VBP*) extremely (*RB*) uncomfortable (*JJ*).

Hence, the feature functions for the 4^{th} word [extremely] are defined by:

$$A_{extremely} = \begin{cases} 1 & \text{if } y_4 = \text{RB and } y_3 = \text{VBP} \\ 0 & \text{otherwise} \end{cases}$$

$$O_{extremely} = \begin{cases} 1 & \text{if } y_4 = \text{RB and } x_4 = \text{extremely} \\ 0 & \text{otherwise} \end{cases}$$

We can rewrite the two feature functions into generalized form $F_k(y_{t-1}, y_t, x_t)$, and thus the conditional probability can be written as:

$$P(y|x) = \frac{1}{Z(x)} exp\left\{\sum_{k=1}^{K} \lambda_k \cdot F_k(y_{t-1}, y_t, x_t)\right\} \tag{1}$$

where

$$Z(x) = \sum_{y} exp\left\{\sum_{k=1}^{K} \lambda_k \cdot F_k(y_{t-1}, y_t, x_t)\right\} \tag{2}$$

is called the partition function (or a normalization factor), which is the summation over all possible combinations of sequences (transitions and emissions). Hence, the most probable label sequence for input sequence x:

$$\hat{y} = \underset{y}{argmax}\, P(y|x) \tag{3}$$

can be found with Viterbi algorithm.

Therefore, the task of review mining can be transformed to an automatic labeling task, and the problem can then be formalized as: given a sequence of words $x = x_1 x_2, \ldots, x_T$ and it's corresponding POS $y = y_1 y_2, \ldots, y_T$, the objective is to find an appropriate sequence of tags which can maximize the conditional likelihood according to *Equation (3)*.

3.2. Parameter Estimation

To estimate the parameters of a linear-chain CRF $\theta = \{\lambda_k\}$, given iid training data $D = \{x^{(i)}, y^{(i)}\}_{i=1}^{N}$, where $x^{(i)} = \{x_1^{(i)}, x_2^{(i)}, \ldots, x_{T_i}^{(i)}\}$ is the observation sequence and each $y^{(i)} = \{y_1^{(i)}, y_2^{(i)}, \ldots, y_{T_i}^{(i)}\}$ is a sequence of the desired predictions (i.e. labels), the conditional log likelihood can be obtained as:

$$\ell(\theta) = \sum_{i=1}^{N} logP(y^{(i)}|x^{(i)}) = \sum_{i=1}^{N} \Big(\sum_{t=1}^{T_i} \sum_{k=1}^{K} \big(\lambda_k F_k(y_{t-1}^{(i)}, y_t^{(i)}, x_t^{(i)}) - \frac{\lambda_k^2}{2\sigma^2}\big) - log(Z(x^{(i)}))\Big) \tag{4}$$

where $\sum_{k=1}^{K} \frac{\lambda_k^2}{2\sigma^2}$ is the $L2$ regularization term added to the likelihood function in order to reduce overfitting. σ is assigned a Gaussian prior and the value of σ^2 is often taken up to 10 (we take $\sigma^2 = 10$ in our experiment). Since in general the function $\ell(\theta)$ cannot be maximized in closed

form, so dynamic programming and L-BFGS algorithm can be used to optimize objective function. The partial derivative, or the gradient of the objective function is computed as:

$$\begin{aligned}\frac{\partial \ell}{\partial \lambda_k} &= \sum_{i=1}^{N} \big(\sum_{t=1}^{T_i} F_k(y_{t-1}^{(i)}, y_t^{(i)}, x_t^{(i)}) - E_{P(Y|x^{(i)})} F(Y, x^{(i)}) \big) - \frac{\lambda_k}{\sigma^2} \\ &= \sum_{i=1}^{N} \sum_{t=1}^{T_i} F_k(y_{t-1}^{(i)}, y_t^{(i)}, x_t^{(i)}) - \sum_{i=1}^{N} \sum_{y} F_k(y_{t-1}^{(i)}, y_t^{(i)}, x_t^{(i)}) P(y_{t-1}, y_t | x^{(i)}) - \frac{\lambda_k}{\sigma^2}\end{aligned} \tag{5}$$

where the first term is the empirical count of feature k in the training data, the second term is the expected count of this feature under the current trained model. Hence, the derivative measures the difference between the empirical count and the expected count of a feature under the current model.

In order to obtain the gradient *Equation (5)*, we need to calculate the conditional probability $P(y_{t-1}, y_t | x^{(i)})$ that requires the sum over the whole label sequence y, which is intractable in a naive fashion. Hence we need to employ some dynamic programming techniques for the calculation.

3.3. Dynamic Programming for CRF Probability as Matrix Computations

For a linear-chain CRF where each label sequence is augmented by $start$ and end states for y_0 and y_{t+1} respectively, the conditional probability of label sequence y given an observation sequence x can be efficiently computed using matrices.

Let $\mathcal{Y}$ be the collection of all possible labels, define a set of $n+1$ matrices $\{M_t(x) | t = 1, \ldots, t+1\}$, where each $M_t(x)$ is a $|\mathcal{Y}_{t-1} \times \mathcal{Y}_t|$ matrix with elements of the form:

$$M_t(y', y|x) = exp(\sum_k \lambda_k F_k(y_{t-1}, y_t, x, t)) \tag{6}$$

Hence, the conditional probability can be written as the product of the appropriate elements of the $n+1$ matrices for that pair of y and x sequences as

$$P(y|x) = \frac{1}{z(x)} \prod_{t=1}^{T+1} M_t(y_{t-1}, y_t | x) \tag{7}$$

The partition function $Z(x)$ is given by the $(start, end)$ entry of the product of all $n+1$ $M_t(x)$

matrices:

$$Z(x) = \Big[\prod_{t=1}^{T+1} M_t(x) \Big]_{start,end} \tag{8}$$

Therefore, the conditional probability can be calculated by a dynamic programming method that is similar to the forward-backward algorithm for HMMs. Define the forward and backward vectors α_t and β_t starting with the base cases:

$$\begin{aligned} \alpha_0 &= \begin{cases} 1 & \text{if } y = start \\ 0 & \text{otherwise} \end{cases} \\ \beta_{t+1} &= \begin{cases} 1 & \text{if } y = stop \\ 0 & \text{otherwise} \end{cases} \end{aligned} \tag{9}$$

and for recurrence:

$$\begin{aligned} \alpha_t(x)^\intercal &= \alpha_{t-1}(x)^\intercal M_t(x) \\ \beta_t(x) &= M_{t+1}(x)\beta_{t+1}(x) \end{aligned} \tag{10}$$

Finally, the conditional probability can be written as:

$$P(Y_{t-1} = y', Y_t = y | x^{(i)}, \lambda) = \frac{\alpha_{t-1}(y'|x) M_t(y', y|x) \beta_t(y|x)}{Z(x)} \tag{11}$$

which can thus be plugged into *Equation (5)* to calculate the gradient.

3.4. Training with Limited-Memory Quasi-Newton Method

The traditional Newton methods for nonlinear optimization require the calculation of the inverse of Hessian matrix (curvature information) of the log likelihood in order to find the search direction, which is impractical. Limited-memory BFGS (L-BFGS) estimates the curvature information based on previous m gradients and weight updates. There is no theoretical guidance on how much information from previous steps should be kept to obtain sufficiently accurate curvature estimates [5]. In our experiment we used previous $m = 10$ gradient and weight pairs, which worked well.

Assume all vectors are column vectors, given λ_k as the updates at the k^{th} iteration, and the gradient $g_k \equiv \nabla f(\lambda_k)$ where f is the objective function being minimized (negative log likelihood). The last m updates of the form $s_k = \lambda_{k+1} - \lambda_k$ and $y_k = g_{k+1} - g_k$ are stored. Define $\rho_k = \frac{1}{y_k^\intercal s_k}$, and $H_k^0 = \frac{y_{k-1} s_{k-1}^\intercal}{y_{k-1}^\intercal y_{k-1}}$ as the initial approximate of the inverse Hessian at k^{th} iteration. The search direction $d_k = -H_k g_k$ can be approached through two-loop recursion [19]:

- 1^{st} *Loop:* Define a sequence of vectors $q_k[q_{k-m}, \dots, q_k] = g_k$ and its element $q_i := \left(I - \rho_i y_i s_i^\intercal\right) q_{i+1}$. Define $a_i = \rho_i s_i^\intercal q_{i+1}$, hence the first recursion calculates $q_i = q_{i+1} - a_i y_i$

- 2^{nd} *Loop:* Define another sequence of vectors where each element $z_i[z_{k-m}, \cdots, z_k] = H_i q_i$. The second recursion calculates $z_{k-m} = H_k^0 q_{k-m}$, thus obtains $b_i = \rho_i y_i^\intercal z_i$ and $z_{i+1} = z_i + (a_i - b_i) s_i$. Hence, the value z_k is the approximation for the search direction. (Note: when performing minimization, the search direction is the negative of z.)

After obtaining the search direction at each step, a backtracking line search method is implemented to find and tune the learning rate (step size) such that it satisfies the sufficient decrease (Armijo) condition given by:

$$f(\lambda_k + \gamma_k d_k) \leq f(\lambda_k) + \sigma \cdot \gamma_k^\eta \cdot g_k^\intercal d_k \tag{12}$$

where γ_k is the step size, $\sigma \in (0, 1)$ is a control parameter and η is the scaling parameter that fits *Equation (12)* iteratively until the condition is met. In our experiment, the initial step size is $\gamma_0 = 0.5$, $\sigma = 0.4$ and $\eta = \{1, 2, \cdots, 20\}$. This step determines the optimal η value, and then the γ_k^η becomes the new step size (learning rate) for the next iteration.

3.5. Path Prediction with Viterbi Algorithm

After training the model, the aim is to find the most probable label sequence for a given sequence with observed words and corresponding candidate part-of-speech tags. The Viterbi algorithm was employed to score all candidate tags with the trained model, and then search the best path that has the maximal score.

Given an observed sequence $X = \{x_1, x_2, \cdots, x_T\}$ (T being the number of tokens in this sequence) with the trained feature (transition and emission) weights being obtained, the most likely state sequence $Y = \{y_1, y_2, \cdots, y_T\}$, where each $y_t \in L = \{l_1, l_2, \cdots, \lambda_V\}$ (L being the label space obtained through training) can be calculated by the recurrence relations (forward step):

$$V_1 = O_{y_1, x_1} \tag{13}$$

$$V_t = \underset{Y \in L}{max}(O_{y_t, x_t} + A_{y_{t-1}, y_t}) \tag{14}$$

where V_t is the score of the most probable state sequence responsible for the first t observations. The Viterbi path can then be retrieved by saving back pointers that remember which state y was used in *Equation (14)*. Let $Ptr(y_t, t)$ be the function that returns the value of y_t used to compute V_t, then we have:

$$y_T = \underset{Y \in L}{max}(V_T) \tag{15}$$

$$y_{t-1} = Ptr(y_t, t) \tag{16}$$

4. EXPERIMENT

We crawled the car review dataset on Toyota and Honda cars from $Cars.com$ using Python Scrapy. A total of 1,126 reviews were collected. After the initial cleaning and duplicates removal, 1,094 reviews were kept. Inspired by [17], additional transformations using regular expressions were performed on the both training and testing dataset as listed in *Table 1*:

Table 1. Transformations

	Regular Expression	Examples
1	sub(r'\'(?![0-9])', ' \' ')	separate [i'm] to [i] and ['m]
2	sub(r'\'(?![A-Za-z])', ' ')	remove ' before numbers, e.g. ['0] to [0]
3	sub(r'\,(?![A-Za-z])|\.(?![A-Za-z])',' ')	remove , or ' inside number, e.g [1,000] to [1000]
4	sub(r'[‘∼!\(\)\[\],::"]+', ' ')	replace punctuations with space
5	sub(r'[A-Za-z]+\d+|[A-Za-z]+\d+([A-Za-z]+)|\d+[A-Za-z]+','#CarModel#')	replace number-letter combinations, e.g. [RAV4] with notation "#CarModel#"
6	sub(r'\d+|\d+\.\d+|\d+\-\d+','#CarNum#')	replace number, e.g. [1000] with notation "#CarNum#"

We tokenized the review sentence into word-level, and then POS tagged each word manually, which was a labor intensive and challenging task. For example, Verb Past Participles (*VBN*) can be used as adjectives (*JJ*) to describe nouns: [I am disappointed in the gas mileage] here we tagged [disappointed] as adjective (*JJ*), whereas most existing taggers including the baseline tagger would automatically tag it as (*VBN*). Similar situations apply to other POS tags such as (*VBG*) vs (*JJ*), etc. as well. In order to ensure that useful information are not discarded during the word extraction process, such words that carry opinion and sentiment information were tagged as (*JJ*).

4.1. Train the CRF POS Tagger

The transformed dataset was then divided into training with 998 reviews and testing with 96 reviews as for such a small dataset, 10% as test samples can provide an intuition about the model. After the pre-processing that included tokenizing the corpus, there are 549 transition features and 2,475 emission features, which means there were a total of 3,024 parameters to be estimated. We

ran the algorithm for 100 iterations, and the negative Log-Likelihood converged quite well, as shown in *Figure 3*:

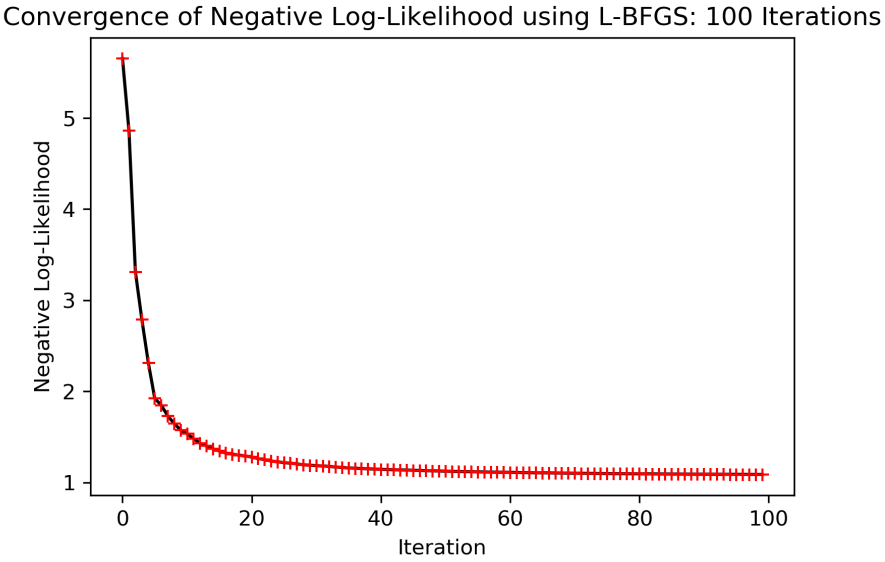

Figure 3. Convergence of Negative Log-Likelihood

Figure 4 shows the distribution of the trained weights, as the majority of the feature weights have values around 0. There are a few features having values that are towards the tails, meaning that certain words are likely/unlikely to emit certain POS tags, or certain transitions, e.g. [*Adjective (JJ)* $\rightarrow$ *Noun (NN)*] vs [*Adjective (JJ)* $\rightarrow$ *Verb (VB)*], are likely/unlikely to happen:

4.2. Performance Evaluation

The performance is evaluated based on precision, recall and F-score. Precision, also referred to as positive predictive value, talks about how precise/accurate the model is out of those $PredictedPositive$, how many of them are $ActualPositive$; Recall is defined as the true positive rate or sensitivity, calculates how many of the $ActualPositives$ the model captures through labeling it as $Positive$ (True Positive):

$$Precision = \frac{TruePositive}{TruePositive + FalsePositive} = \frac{TruePositive}{TotalPredictedPositive} \tag{17}$$

$$Recall = \frac{TruePositive}{TruePositive + FalseNegative} = \frac{TruePositive}{TotalActualPositive} \tag{18}$$

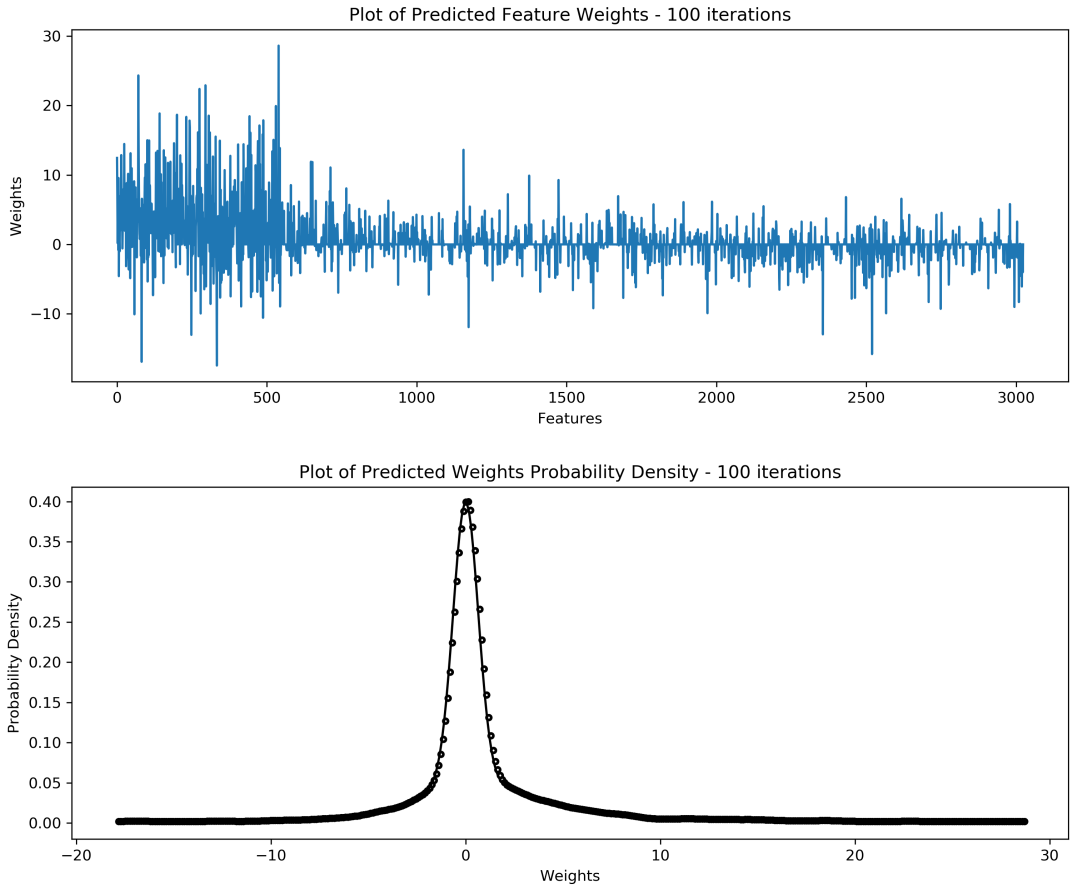

Figure 4. Distribution of Predicted Feature Weights

and F_1 score is the harmonic mean of the precision and recall, which helps seek a balance between precision and recall:

$$F_1 = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}} \tag{19}$$

We computed both macro and micro values for precision and recall. Macro-average computes the metric independently for each class and then takes the average (treating all classes equally), whereas micro-average aggregates the contributions of all classes in the computation. In a multi-class classification setup, micro-average is preferable if one suspects there is class imbalance.

4.2.1. Validation

To validate our CRF model, we incorporated 10-fold cross-validation where the training set were randomly partitioned into 898 for training and the rest 100 for validation. Further, after each cycle we would reshuffle the training set and go through the 10-fold CV process again. The process was repeated 20 times to ensure the generality of our proposed CRF model. Hence, we obtained 200 validation results and calculated the three metrics accordingly, with corresponding means and standard deviations listed in *Table 2*:

Table 2. Validation Performance - Mean, Standard Deviation and 95% C.I.

	Precision	Recall	F_1
Mean	0.9423	0.9224	0.9202
Standard Deviation	0.0218	0.0212	0.0212
95% C.I.	[0.9393, 0.9453]	[0.9195, 0.9253]	[0.9173, 0.9231]

The histograms of three metrics for the 200 validation models displayed in *Figure 5* indicate a good overall performance, as the lower bounds of the 95% confidence intervals rest above our threshold of 90% set for the metrics, hence no furthur model tuning is requried at the moment.

4.2.2. Testing

We then moved onto the testing set, *Figure 6* displays the confusion matrix, where the overall accuracy is 0.9252 (however, overall accuracy is not a metric to use when evaluating a model):

Table 3 shows the average precision, recall and F_1 metrics:

Table 3. Overall Performance - Precision, Recall and F_1

	Precision	Recall	F_1
Macro	0.9322	0.9290	0.9264
Micro	0.9352	0.9352	0.9352

We also computed these metrics for each label (a total of 31 labels in our experiment) that are displayed in *Table 4*. Our tagger managed to capture each POS feature fairly well, given such a small data set.

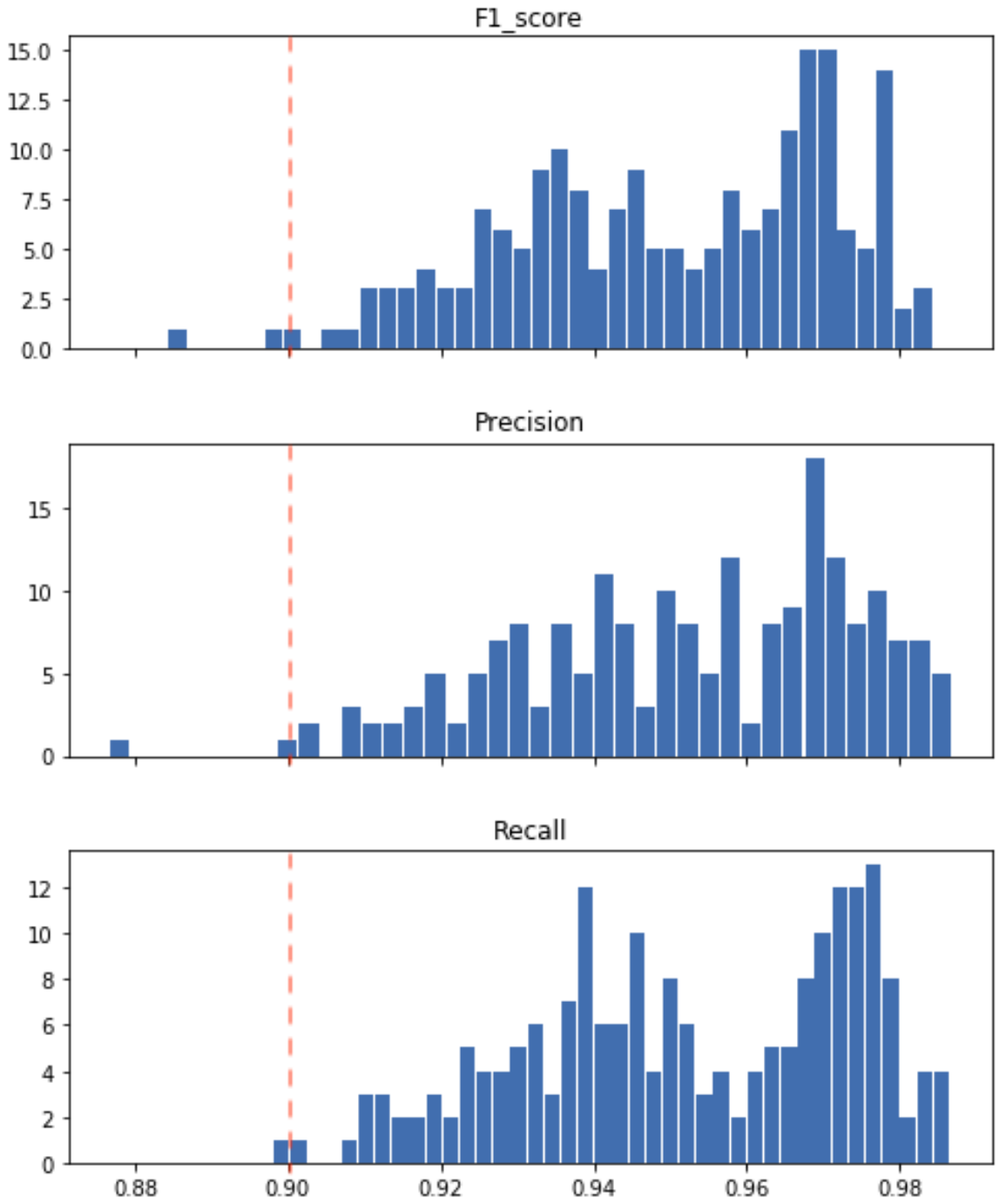

Figure 5. Histogram of Performance Measures - Validation 200 Times

The error matrix displayed in *Figure 7* shows the details of mis-predicted classes, and we see that most misclassified tokens were between *VBZ* and *NNS* where both words would end with an ”s”:

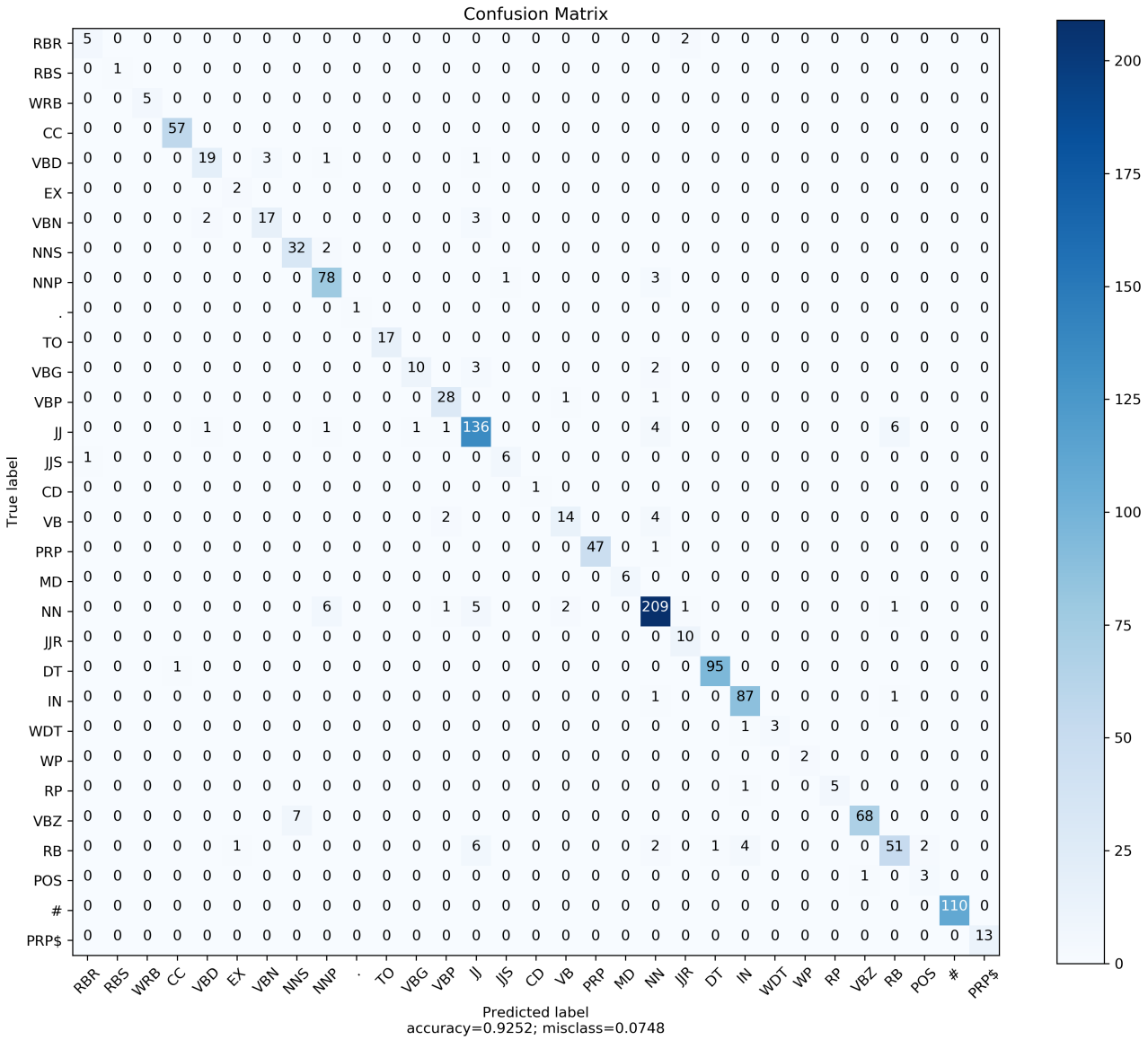

Figure 6. Confusion Matrix

Based on the above metrics, CRF performed really well in sequential labeling for reviews on Toyota and Honda cars. Taking the first sentence in our testing data as an example, the comparison of the true path and predicted path is shown in *Table 5* where the only misclassification was on the word [inside]:

4.2.3. Comparison

We compared the performance of CRF tagger to the baseline tagger in Python NLTK 3.3. The side-by-side comparision is displayed in *Table 6*. The performances of the two competing

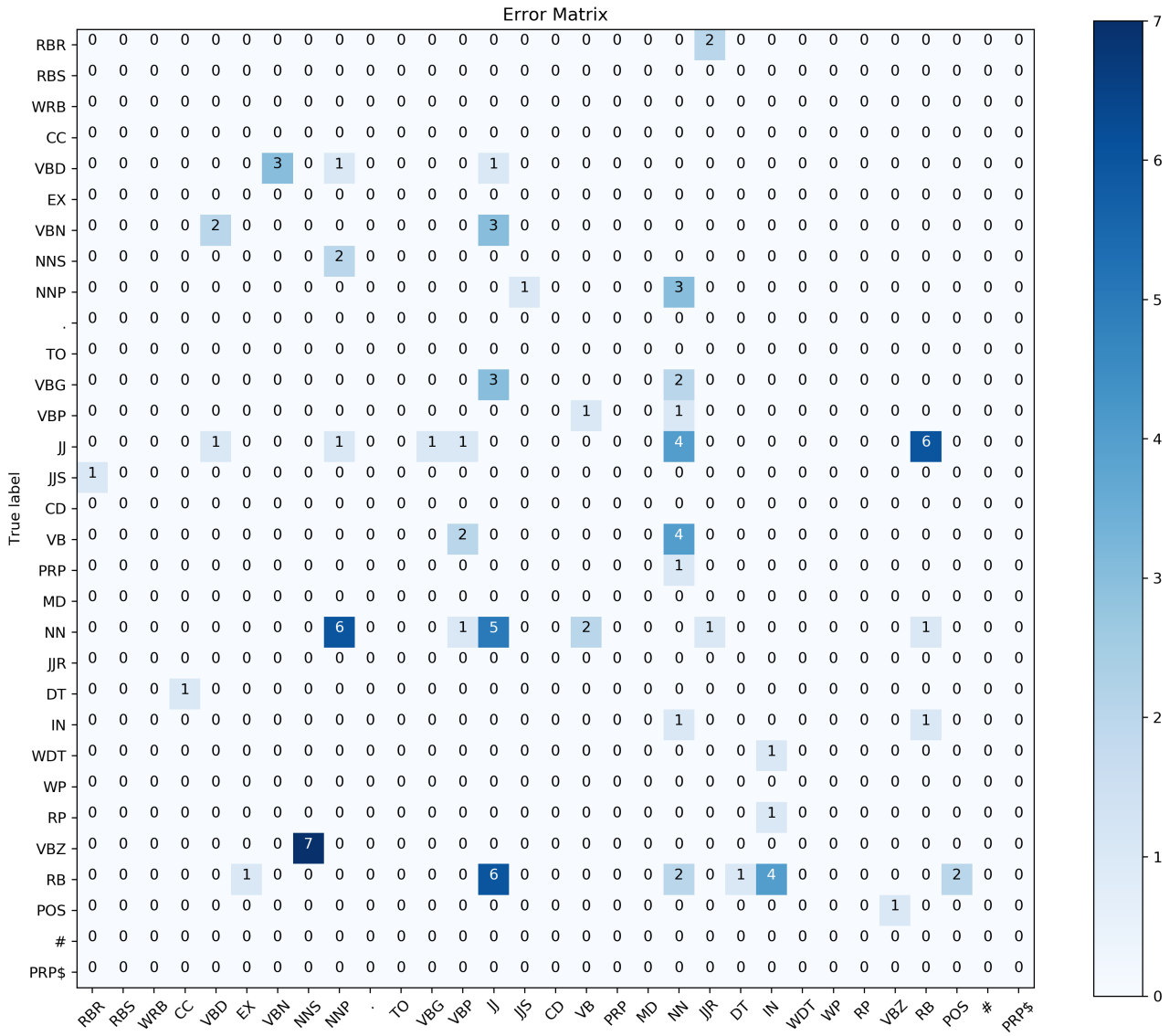

Figure 7. Error Matrix

taggers were very close. However, as we observed from the tagging results, that the performance of the baseline tagger has been inconsistent, as it has a tendency to classify any word with first letter capitalized to *NNP*, e.g. [Gas] and [Nice] would be classified as *NNP* instead of the ground truth of *NN* and *JJ*. With larger testing set, CRF will outperform the NLTK baseline tagger and the differences will be distinct, as our model that was trained only on this small sample can reach a similar level of performance compared to the pre-trained NLTK baseline tagger which has already been trained over millions of text samples.

Table 4. Performance on Individual Tags - Precision, Recall and F_1

POS Tag	Precision	Recall	F_1
RBR	0.8333	0.7143	0.7692
RBS	1	1	1
WRB	1	1	1
CC	0.9828	1	0.9913
VBD	0.8636	0.7917	0.8261
EX	0.6667	1	0.8
VBN	0.85	0.7727	0.8095
NNS	0.8205	0.9412	0.8767
NNP	0.8864	0.9512	0.9176
.	1	1	1
TO	1	1	1
VBG	0.9091	0.6667	0.7692
VBP	0.875	0.9333	0.9032
JJ	0.8831	0.9067	0.8947
JJS	0.8571	0.8571	0.8571
CD	1	1	1
VB	0.8235	0.7	0.7568
PRP	1	0.9792	0.9895
MD	1	1	1
NN	0.9207	0.9289	0.9248
JJR	0.7692	1	0.8696
DT	0.9896	0.9896	0.9896
IN	0.9355	0.9775	0.9560
WDT	1	0.75	0.8571
WP	1	1	1
RP	1	0.8333	0.9091
VBZ	0.9855	0.9067	0.9444
RB	0.8644	0.7612	0.8095
POS	0.6	0.75	0.6667
#	1	0.8333	0.9091
PRP$	1	1	1

Table 5. Example: Tagging Output &. Comparison

Original sentence	The car is roomy inside, comfortable, handles and performs great and is fun to drive.
Processed sentence	the car is roomy inside comfortable handles and performs great and is fun to drive
True Path	*DT NN VBZ JJ IN JJ VBZ CC VBZ JJ CC VBZ JJ TO VB*
Predicted Path	*DT NN VBZ JJ RB JJ VBZ CC VBZ JJ CC VBZ JJ TO VB*

Table 6. Performance Comparison: CRF vs NLTK Baseline Tagger

	Precision	Recall	F_1
CRF	0.9322	0.9290	0.9264
NLTK Baseline Tagger	0.9248	0.9210	0.9201

5. FEATURE EXTRACTION

After successful training of the CRF tagger, we then extracted features based on the tagging result. As the first step, we extracted only Nouns and Adjectives from the review sentences as these words contain the most information one would need to generalize the ideas. An example shown in *Table 7* below gives the idea about how it works:

Table 7. Example: Word Extraction from Review Sentence

Original sentence	The car is roomy inside, comfortable, handles and performs great and is fun to drive.
Processed sentence	the car is roomy inside comfortable handles and performs great and is fun to drive
Predicted Path	*DT NN VBZ JJ RB JJ VBZ CC VBZ JJ CC VBZ JJ TO VB*
Extracted words	car roomy comfortable great fun

When one is interested in finding out how people think about a specific feature, e.g. transmission, our framework takes in the key words [transmission, transmissions] and output any summarized reviews that contain these key words:

From the generalized report on feature *transmission* as shown in *Table 8*, people will get abundant information on how transmission performs.

Table 8. Summarized Report on Feature: Transmission

'transmission', 'jerky', 'gas', 'mileage', 'terrible'
'transmission', 'not'
'lack', 'power', 'transmission', 'problem', 'car', 'down', 'shifts'
'transmission', 'smooth'
'problem', 'transmission', 'computer', 'chips', 'difference'
'transmission', 'cruise', 'control', 'joke'
'miles', 'auto', 'shop', 'times', 'last', 'call', 'dealer', 'transmission'
'transmission', 'not', 'smoothest'
'hp', 'speed', 'auto', 'transmission', 'responsive', 'smooth'
'new', 'transmission', 'not', 'smooth', 'accelerating', 'stop'
'speed', 'transmission', 'shifts', 'manual'
'transmission', 'computer', 'major', 'issue'
'transmission', 'jerky', 'gas', 'mileage', 'terrible'
'major', 'transmission', 'issues', 'twice'
'transmission', 'driving', 'crazy'
'transmission', 'absolute', 'worst', 'dangerous', 'cause', 'accident'
'manual', 'transmission', 'lack', 'power', 'great', 'fuel', 'economy'
'transmission', 'big', 'issue', 'rattles', 'more', 'miles'

6. SUMMARY

We proposed and built a CRF based framework that can extract keywords associated with product features and summarize into concise lists that are simple and intuitive for people to read. The advantage of CRF is that it makes fewer assumptions than the generative models, and hence allows a great level of flexibility on feature engineering. Taking our case as an example, since we only extracted information that are carried by the Nouns and Adjectives at the current stage, some information that are carried by verbs or verb phrases such as ”recommend”, ”outperform”, ”disappoint”, etc. are not inherited. One way to accommodate such information is to engineer another feature for entity chunking or named-entity recognition (NER), which will also fine-tune the performance of extraction to let it further separate different features chunks in a single sentence, e.g. differentiate the transmission chunk and the gas mileage chunk from [’transmission’, ’jerky’, ’gas’, ’mileage’, ’terrible’].

The current CRF model can be further expanded to more accurately tackle problems mentioned above by introducing a set of self-defined entities and corresponding features functions listed in the following table [7]:

Table 9. Different Types of Entities

Components	Pysical objects of a product, e.g. engine, transmission, brake, seat ...
Functions	Capabilities provided by a product, e.g. horsepower, acceleration, adjustable seat ...
Features	Properties of components or functions, e.g. mileage, confort, size, color, design ...
Opinions	Thoughts expressed by users on components, functions or features

For word that is not an entity, it will be represented as background word by (B). Furthermore, an entity can be a single word or a phrase. For phrase entity, a position feature is assigned to each

word in the phrase, and there are three possible positions denoted at beginning of the phrase (*Entity-B*), middle of the phrase (*Entity-M*) and end of the phrase (*Entity-E*). As for opinion entity, polarity can be represented by positive (*P*) and negative (*N*), and use (*Exp*) and (*Imp*) to respectively indicate explicit opinion (opinion expressed explicitly) and implicit opinion (opinion needs to be induced from the review). Taking sentence in *Table 5* as an example [*the car is roomy inside comfortable handles and performs great and is fun to drive*]:

Table 10. Label with New Tags

Original sentence	The car is roomy inside, comfortable, handles and performs great and is fun to drive.
Processed sentence	the car is roomy inside comfortable handles and performs great and is fun to drive
POS tags	*DT NN VBZ JJ RB JJ VBZ CC VBZ JJ CC VBZ JJ TO VB*
Hybrid tags	*B Component-B B Opinion-B-P-Exp Feature-B Opinion-B-P-Exp Feature-B B Feature-M Opinion-B-P-Exp B B Opinion-B-P-Exp Feature-M Feature-E*

Where in the sentence, [car] is the component of a car, [inside], [handles], [performs] and [to drive] are features of a car. [Roomy] is a positive, explicit opinion expressed on the feature [inside], so it is tagged as the hybrid tag (*Opinion-B-P-Exp*). Therefore, after obtaining all the hybrid tags, we can identify the opinion orientation if a word is an opinion entity. Thus, second-order feature functions can be expanded on top of the first-order feature function defined in 3.1. For example, if the current word x_t is [disappointed], the corresponding POS y_t is *JJ* and the current entity state e_t

is *Opinion*, one possible way to engineer the second-order feature is:

$$F_k(e_{t-1}, e_t, x_t, y_t) = \begin{cases} 1 & \text{if } e_t = \text{Opinion, } x_t = \text{disappointed and } y_t = \text{JJ} \\ 0 & \text{otherwise} \end{cases}$$

which can then be incorporated into the likelihood function and hence follow the same procedure to train a new model. We will not go any deeper at the moment but we would like to show the flexibility of feature engineering and the ability to strengthen the model on top of the same framework.

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APPENDIX A. PENN TREEBANK PART-OF-SPEECH TAGS

Tag	Description	Examples
$	dollar	$ -$ –$ A$ C$ HK$ M$ NZ$ S$ U.S.$ US$
“	opening quotation mark	‘ “
”	closing quotation mark	’ ”
(	opening parenthesis	([{
)	closing parenthesis)	)] }
,	comma	,
–	dash	–
.	sentence terminator	. ! ?
:	colon or ellipsis	: ; ...
CC	conjunction, coordinating	& ’n and both but either et for less minus neither nor or plus so therefore times v. versus vs. whether yet
CD	numeral, cardinal	mid-1890 one-tenth million 0.5 one 1987 ’79 IX ’60s .025 271,124 dozen quintillion DM2,000 ...
DT	determiner	all an another any both del each either every half la many much nary neither no some such that the them these this those
EX	existential there	there
FW	foreign word	gemeinschaft hund ich jeux habeas Herr K’ang-si vous lutihaw alai je jour fille ...
IN	preposition or conjunction, subordinating	astride among uppon whether out inside pro despite on by throughout ...
JJ	adjective or numeral, ordinal	third ill-mannered pre-war regrettable ...
JJR	adjective, comparative	cheaper choosier cleaner ...

Tag	Description	Examples
JJS	adjective, superlative	cheapest choicest classiest ...
LS	list item marker	A A. B B. First G H I ...
MD	modal auxiliary	can cannot could couldn't dare may might must need ought shall should shouldn't will would
NN	noun, common, singular or mass	cabbage knuckle-duster Casino ...
NNP	noun, proper, singular	A.K.C. Meltex Liverpool ...
NNPS	noun, proper, plural	Americans Americas ...
NNS	noun, common, plural	undergraduates scotches ...
PDT	pre-determiner	all both half many quite such sure this
POS	genitive marker	' 's
PRP	pronoun, personal	hers herself ownself self she ...
PRP$	pronoun, possessive	her his mine my our ours their thy your
RB	adverb	occasionally unabatingly ...
RBR	adverb, comparative	further gloomier grander ...
RBS	adverb, superlative	best biggest bluntest ...
RP	particle	aboard about across along ...
TO	"to" as preposition or infinitive marker	to
UH	interjection	Goodbye Goody Gosh Wow ...
VB	verb, base form	ask assemble assess ...
VBD	verb, past tense	dipped pleaded swiped ...
VBG	verb, present participle or gerund	telegraphing stirring focusing ...
VBN	verb, past participle	multihulled dilapidated ...
VBP	verb, present tense, not 3rd person singular	predominate wrap resort ...
VBZ	verb, present tense, 3rd person singular	bases reconstructs marks ...
WDT	WH-determiner	that what whatever which whichever
WP	WH-pronoun	that what whatever whatsoever which who whom whosoever
WP$	WH-pronoun, possessive	whose
WRB	Wh-adverb	how however whence whenever where whereby whereever wherein whereof why
SYM	symbol	% & ' " ".)). * + ,. ¡ = ¿ @ A[fj] U.S U.S.S.R * ** ***

APPENDIX B. CAR REVIEWS RAW DATA

1 Driver’s seat not comfortable, the car itself compared to other models of similar class .
2 It’s very comfortable, remarkably large inside and just an overall great vehicle .
3 Front seats are very uncomfortable .
4 I like the wood grain accents with the tan colored interior but I don’t think is looks as good with the gray interior .
5 I’m 6’ tall, and find the driving position pretty comfortable .
6 However, there are a couple of things that kill it for me 1 terrible driver seat comfort, kills my back 2 lack luster interior design, my Acadia has much better comfort 3 the VCM drives me crazy because the constant change in cylinder use is perceptible enough to be an annoyance .
7 The seats are extremely uncomfortable .
8 The interior is upgraded markedly, and although there is a bit less headroom, the added telescoping feature of the steering wheel combined with the greater travel of the seat yields greater comfort .
9 While the Accord is no Acura it is a close relative in terms of quality and comfort .
10 I previously owned a 98 Avalon, and found the seats more comfortable than the Honda .
11 I’m very sad , I loved my daughter’s Civic and the dealer service is fantastic, but even good service can’t help the uncomfortable seats .
12 I would not have purchased this vehicle if I was aware of the actual poor mileage .
13 Overall performance is good but comfort level is poor .
14 Power is great, transmission shifts are smooth and accurate .
15 Instead of giving me a new car they finally admitted the problems with transmission and replaced it with a new one, free of cost to me cost to them .
16 The best gas mileage I have achieved for this 4 cyl .
17 I had always heard that Toyota had the best quality cars .
18 The car achieves a nice balance between sportiness and comfort .
19 There are so many interior improvements and well as engineering improvements .
20 I admire engine performance and comfort while driving atleast 30 mile a day to job .
21 The previous models were boring both aestically and performance wise .
22 The transmission hesitates and stumbles .
23 5 in nob the display under the speedometer could be more helpful telling me how many miles gallon I have, telling me how my speed affects my gas mileage .
24 The ride is a great balance between handling and comfort .

25 Surprisingly agile for a 4 cyl, auto transmission requires manual downshift for quick instant power .
26 While driving on the interstate with the window down, the wind makes an annoying sound as it bounce against the interior of the car .
27 Although it is fun to drive and quality seems ok, the leather seats are very uncomfortable, especially on a long drive .
28 Although not the fastest, most luxurious, or technologically advanced in the very competitive mid, size sedan segment, the Accord strikes the perfect balance of sport, comfort and value , creating a vehicle that feels and acts like a much pricier machine .
29 Has lots of features, is comfortable, everything works .
30 It can occasionally accelerate quickly and jerk you ahead, or hesitate, and sometimes I've noticed the car slow down unnaturally via the transmission .
31 The two door coupe is very comfortable and roomy and draws plenty of attention .
32 Additionally, the standard seats are not my favorite .
33 Extremely comfortable with 3 separate power driver seat adjustments .
34 00 per gallon I wanted something more fuel efficient but large enough to seat four adults comfortably and provide a sense of safety too .
35 The seat is extremely uncomfortable .
36 I love the car's visual and aesthetic design, but quality is just as important and for that reason, I would NOT recommend the new Camry to anyone !
37 The driver's seat is very uncomfortable .
38 Nowhere near the mileage the sticker shows .
39 The VCM definitely helps the mileage , it was very noticeable when it activated in the beginning, but is barely detectable now, except for the dash indicator .
40 The head rest tills forward which pushes the driver's head forward at a very uncomfortable position .
41 The front driver seat's lumbar support seemed very uncomfortable at first .
42 Its ride, comfort and overall performance is an absolute joy .
43 The car is comfortable and QUIET .
44 transmission hunts for gears, ride quality much worse than even a mediocre car, Auto sound level doesn't work, accessory outlets do not work unless car is running or ac is on , radio shuts off when engine is shut off .
45 No big deal The car is huge and very comfortable .
46 Very tight, runs great, very comfortable to drive .
47 The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats .
48 Initially the dashboard controls were a little intimidating, but

it doesn’t take long to get comfortable with them .
49 I fit in the Coupe comfortably .
50 The driver seating is uncomfortable .
51 It’s a comfortable ride and is very high quality .
52 For a 4 cylinder car I am surprised at the comfortable and peppy drive .
53 This a good choice if you need an affordable and comfortable commuting vehicle but hate the idea of a boring boxy sedan .
54 What a car, design, ride, comfort, 270 watt audio system, I love this car .
55 The seats are very comfortable & supportive .
56 I like my Accord very much, but had I known the drivers seat was so uncomfortable I would have never bought it .
57 Aside from missing the turbo’s acceleration, I’ve preferred the Accord’s better mileage, handling and comfort .
58 This Accord is the only large car I found with upscale comfort amenities and a good manual transmission .
59 Comfort inside is better than expected .
60 My family of 5 can comfortably ride in this car .
61 This car is a dream from the GAS to the STYLE to the COMFORT .
62 Its the most comfortable Accord I have had .
63 I do find the lumbar on the driver’s seat a bit uncomfortable though .
64 The car is very comfortable, the steering is tight and precise .
65 The seats are comfortable, and there is ample leg room in the front and rear .
66 Most uncomfortable seats in any vehicle I have ever owned .
67 It is very comfortable, easy to drive and park .
68 I would recommend this car for great value, comfort, & fun to drive !
69 Seats are firm but not uncomfortable , very BMW like .
70 I’ll probably sell it to avoid an expensive transmission repair after the extended warranty expires .
71 Rides with comfort and motor will pick up if you need it .
72 It gives a sporty driving feel and offers a very comfortable Highway ride .
73 Uncomfortable in Camry, Had a Nissan before, rough ride .
74 Test drove Honda and enjoyed the firm yet very comfortable ride .
75 It’s very comfortable, has pretty much every luxury feature you might want, and is still fun to drive .
76 DON’T rely on your test drive, the seats are Very uncomfortable and when the engine goes into the econo mode the vehicle shifts rocks violently forward and when leaving the econo mode it shifts rocks forward once again which means that the vehicle is CONTINUOUSLY SHAKING AND ROCKING .
77 Seats are very comfortable and ride is very smooth !
78 My only complaint is comfort .
79 The front seats are extremely uncomfortable after anything more

than 15 minutes of driving due to what I see as a design flaw, the seat curvature is too great, and even with the lumbar support all the way retracted, it still feels like there is some type of bar sticking out in the wrong part of my back .

80 However, the 08 Accord is well designed, handles well for its size and the comfort level is so much better than the TL .

81 Absolutely got a great car, roomy, comfortable, great ride for a nice price .

82 Fun to drive, safe, reliable, and comfortable .

83 Driver's seat is not fully adjustable using 8, way power seat which is very uncomfortable .

84 The car is solid, beautiful, comfortable, fuel efficient and big enough for my family of 5 .

85 Everyone loves the way it rides and we took it to the lake without a single complaint of comfort .

86 Driving 55 miles per hr between Houston and Austin this slow is very painful, boring to drv,Our Avalanche averaged 15 city with a very comfortable seat and only 20 highway but the vast majority of our driving is in the city not a good trade off .

87 At 6'5 it is very comfortable .

88 Good looking inside and out, comfortable and roomy, commendable performance, and excellent gas mileage .

89 However, long, distance comfort is poor due to hard, narrow and deeply, bucketed seats combined with a very taut suspension which transmits even minor road imperfections through the whole vehicle .

90 The seat contour creates uncomfortable pressure points which quickly become tiring and downright painful .

91 The Camry was very comfortable, but not sporty and the ride was boring .

92 s a great car, spacious, comfortable, fun to drive, and handles very well .

93 At first the seats seemed stiffer than I'd like, but after making a 2 1 2 hour trip, It felt very comfortable once I got the seat and lumbar adjusted to my liking .

94 extremely comfortable, more power than camry, lots of space, good fuel economy, and mean looking Cons :

95 Ride, comfort, visibility, braking, steering and acceleration are excellent for a car of its size and price .

96 The '08 is more comfortable and handles quite a bit better than the very good experience we had with the '06's .

97 Door closure is solid, leather seats are very comfortable .

98 From the hard and uncomfortable driver seat, excessive body roll, several rattles in the interior and intrusive road noise, the vehicle just does not strike a chord n .

99 In fact, I find my 2006 Civic Ex w Nav to be a better built, more comfortable and more engaging car .

100 Lots of room and very comfortable .

101 I purchased this car because the amount of time I spend on the road, I need a comfortable car that is reliable .
102 This car is comfortable, loaded with options and every one that gets into it loves it .
103 Seats are not very comfortable and not happy with the heated seats .
104 The seats are very comfortable and I love the cloth .
105 The Accord has looks, comfort, great ride and reliability .
106 Ample room for someone that is 6’2 , and extremely comfortable for my daily commute .
107 An extremely comfortable and capable sedan .
108 I previously had a ’01 Acura CL Type, S and the ride is similar interior design not all that much different than the TL and on the EX, L you get most of the same options plus the added roominess in the ’08 helps w a family .
109 I went for comfort over performance to fit it in my budget so the EX, L with the 4 cyl engine .
110 So far, the reliability has been as expected, it is comfortable on my back, and the gas mileage has been pretty good .
111 The interior design is roomy and very comfortable .
112 Steering nice and tight, seats a little stiff but comfortable .
113 Interior is very roomy, and I can sit comfortably in the rear seat at 6’2 .
114 Great car, really comfortable and quiet .
115 Solid build, comfortable interior, smooth ride, fuel efficient averaging 27 .
116 This is my second Accord and it’s bigger, zippier and more comfortable .
117 This car is stylish and very comfortable to drive .
118 It is comfortable, easy to drive, and fast !
119 Very comfortable and roomy vehicle .
120 The ride is firm but not harsh, It is more comfortable than the Maxima and looks much better than any Camry .
121 I previously owned a Chrysler 300 2006, so it is difficult going from a real comfortable interior, really massive dash to a bland and old fashioned interior .
122 Fun to drive, economic, very comfortable, and excellent on the highway .
123 It’s much more comfortable than the Vette and I absolutely love driving it .
124 It has great handling and does so with comfort .
125 Have to say the comfort, look, design and how it drives is first rate .
126 Back seat comfort and entry exit are great .
127 Ride is superior, comfortable seats, radio excellent .
128 my first fill up was 26 mpg mixed city and hwy I only expect it to get better, steering is tight and precise, only complaints are road noise is more than i like but its livable, rain or

just dew pours in right on top of the power window controls when the window is cracked, but window guards have fixed that, its a fun car to drive, and for what it is, its comfortable, controls are great, easy to reach, I'm looking forward to a lot of great miles with this car .
129 The Honda was very comfortable to drive and averaged 32 miles per gallon .
130 The leather seat is not the most comfortable, but not bad .
131 I drive 140 miles daily, and found the comfort the best feature .
132 It drives well, the satellite radio is awesome and it has the comfort of home .
133 It has a comfortable ride and most controls are logical, but the location of the volume knobs takes some getting used to .
134 Excellent car, would recommend this to anyone looking for a sharp , reliable, comfortable sedan .
135 A little pricy but it's really a comfortable car and a great driving machine .
136 Great comfort in the Accord .
137 Awesome interior with great comfort .
138 Three months and I still can't get comfortable in the LX .
139 For test drive , I wish I had removed the hard plastic from the driver's seat tried harder to get comfortable in the non, electric seat spent more time on rough roads .
140 but I do miss the more comfortable ride of my '05 & '96 Camry's .
141 Otherwise the car is comfortable, stylish, spacious and it handles well .
142 Very comfortable ride compared to my Lexus .
143 My main reason for purchasing this car was to get a fuel, efficient vehicle that also was comfortable to drive on long trips .
144 Interior is nice but not as comfortable as past Accords and feels a little cheap .
145 I am extremely satisfied after the first week though it was more costly, I still like the smooth power and handling of the V, 6, the comfort of the leather interior, and something new for me .
146 This is by far the most comfortable vehicle I have owned .
147 When I bought this car a year ago, I initially wrote a review stating I may have buyer's remorse due to extremely uncomfortable driver's seat .
148 Ride seems comfortable and gas mileage fairly good averaging 26 city and 30 open road .
149 Seats are fine, in fact of all the smaller sedans this is the most comfortable I found for the price as I am 6', 2 and 250# .
150 Great gas mileage and comfortable on long trips .
151 Good gas mileage, comfortable seating, lots of leg room .
152 Lots of comfort for the price .

153 The ride is loud and not comfortable .
154 I drive 2 hours to work each day and it is just not comfortable to me .
155 Getting about 26 mpg mixed city hwy with conservative driving, seating 4 people comfortably .
156 The ride is quiet and comfortable .
157 Styling is bland, the engine isn't strong at all, and the car doesn't deliver good comfort while driving it .
158 The seats aren't comfortable either .
159 It is relatively comfortable inside .
160 It's a pretty good car, reliable, comfortable as far as it goes, but limited rear visibility because of high rear bumper, and a problem with its computer learning my driving style .
161 The driver seat is still soft and mostly uncomfortable .
162 The ride is comfortable and it seems to ride a little higher than the average sedan, which I like .
163 I've had 3 BMWs and only one of them could offer a more comfortable ride than the Camry .
164 Second the internal comfort id awful .
165 The previous soft seats were replaced with hard cheap ones which are very very uncomfortable and give me back pain .
166 If you keep in mind that the Camry is a comfort car, you may even enjoy the experience .
167 While the 4 cylinder does not have the punch of the Honda Accord 4 cylinder, the comfort and quietness of the ride won out .
168 No hestitation, comfort is great in front in back .
169 I feel uncomfortable driving this car and will get rid of it .
170 Very comfortable, great styling .
171 I was surprised by how quiet the cabin was and just how comfortable it was to sit in and drive .
172 This car offers poor driver's seat comfort, poor vision , only average ride quality, gas mileage
173 We have had this Camry about two years now, and it is not a boring car but it is smooth, comfortable and has good road manner, and overall it is a good car .
174 I'd highly recommend anyone buy this car if they are seeking an affordable, comfortable, reliable vehicle .
175 You can not get that comfort with any other automaker other than perhaps Honda .
176 Looks are great and interior is comfortable, but it ?
177 I needed a comfortable commuter that I could also run around with the family in .
178 great ride, quiet comfortable spacious cabin, superior electronics , fair price and good looks .
179 You can't have it both ways, either a car is full of power and stiff suspension or it's smooth and comfortable on the road .
180 The interior is very luxurious and comfortable, however the car feels slower than my 2002 Camry LE .

181 For the comfort and entertainment of the ride, I like the Camry .
182 The driver’s seat is really comfortable .
183 I have had no transmission issues or rattling, the comfort and ride of this vehicle felt to me much more high end then what I had paid .
184 I love the look, and the comfort, but would never buy one again .
185 I’ve read other reviews stating that the leather seats were not comfortable for long drives due to lack of cushion support, but that’s not been the case for me especially after recently driving from Houston to Key West, Fla .
186 The seats were very comfortable .
187 The car comfort, looks, performance and fuel economy are great but the paint is a disaster .
188 Front seats are not comfortable on long trip .
189 I was not sure at first about trading my 01 Honda Accord but have been more than satisfied with the performance, looks, and comfort .
190 A little stiffer ride than the xl and xle models I have had, but still comfortable and quiet .
191 Very comfortable ride and seating .
192 Very low interior noise level, which adds to the long trip comfort .
193 The ride, comfort, and drive is as expected, however, the quality and reputation of yore are completely gone for the flagship Camry .
194 Over the month it was in the shop, we rented several different cars and nothing seemed to measure up to the comfort and options of the Camry .
195 The seat comfort is not as it was and I found that the gas, brake pedals are offset too much to the left of my body centerline .
196 Very comfortable, quiet interior .
197 Seats are padded more firmly than previous model but comfortable on trips .
198 Feels expensive, yet comfortable with larger interior than my Grand Prix .
199 Trunk is big and rear seat very comfortable for 2 and will seat 3 .
200 Headroom body room comfort great for my 6’1 250 lbs .
201 I feel that the Camry just gets better and better in terms of comfort, styling and performance with each generation .
202 It looks awesome, turns like it’s on rails, has a great sound system, and is just comfortable and fun to drive .
203 It is very quiet and comfortable .
204 Smooth, comfortable, reliable, fast .
205 Very comfortable seating position for both me and my husband .
206 The interior is extremely comfortable, and spacious .
207 For the price I couldn’t have asked for a better performing,

comfortable and stylish whip .
208 The seating is relatively comfortable .
209 Other than that, technology is mind blowing on this sedan and performance is incredible, with a smooth and comfortable ride .
210 I’m 6’3 and I find this car very comfortable to drive or ride in .
211 My friends say my car is just like a Lexus and I have to agree, very comfortable and beautiful .
212 Seats are comfortable, but wish the seat bottoms tilted back more into a bucket position .
213 Solid, high quality, comfortable and quiet .
214 Uncomfortable head restraint, too close to my head .
215 Superb handling, performance and comfort .
216 Turns out, it was one of the smoothest, most comfortable rides ever .
217 I bought this car smitten by its exterior look and interior comfort .
218 Yes, it is very comfortable, esp for the price paid .
219 Very quiet and comfortable ride, more than enough power .
220 It is very reliable and comfortable .
221 It’s very comfortable and a quiet ride with low levels of road and wind noise .
222 The seats are way to low to the ground making long drives uncomfortable .
223 I do not find the front seats as comfortable as the seats in my old 96 Ford taurus .
224 Toyota made many improvements since 03, including more comfortable front seats, better rear seat room and comfort .
225 Very comfortable, quite and smooth ride .
226 The sound system is incredible, the seats are comfortable, the controls are ergonomic and straight forward and the take off power is quite impressive .
227 My passengers are expecially happy with it and love the room, comfort, and adjustability .
228 On longer trips, however, they have a tendency to fall asleep, , which I think emphasizes how comfortable, smooth, and quiet it is .
229 It is a very comfortable car that gives us options that we never had on previous vehicles .
230 I test drove and compared similar 4 door sedans like the Maxima, Accord, Mazda6, and noticed that none had all the features, performance,comfort ,safety,and looks that the Camry has .
231 The navigation works flawlessly, comfortable seats .
232 I have to say the car rode great,comfortable and gas mileage great .
233 I would recommend this car to anyone looking for a comfortable ride as well as good fuel economy .

234 The seats were very comfortable on a four and a half hour trip, and wind and road noise were minimal .
235 The interior is much more comfortable than my last 3 Camrys and the exterior styling is oh so chic .
236 Comfortable and quiet with excellent gas mileage .
237 Comfort is great, mileage is good overall, better on the road than expected , compared to my 1999 Camry .
238 Having flown 26 different aircraft and driven cars for 61 years, I find the 2007 Camry to be the most uncomfortable cockpit I have every been in .
239 The headrest presses into my head at an uncomfortable angle and it is imposssible to tell where the front of the car is for parking .
240 The window sill is too high and the armrest too low to be comfortable .
241 The new looks are what attracted it to me initially, but its relatively smooth drive, comfort and reliability sold me on it .
242 It is a beautiful sapphire blue, has really nice lines, is very comfortable, is plenty peppy, and hugs the road .
243 The ride is very comfortable, although I'm 6'6 and I didn't think head room was an issue but I do think leg room could be better, I think this is mainly because the back seats have tons of leg room .
244 It is so comfortable and drives perfect .
245 Overall this car is very quiet, comfortable, smooth, powerful, and absolutly the best mid, size in the current market .
246 Leather seats are comfortable, Nav system is easy to use .
247 I only have a vibration shimmy problem at 70 mph, visited dealer three times and ended up with changing a new tire and now the ride is even quieter and comfortable .
248 Ride seems comfortable and gas mileage fairly good averaging 26 city and 30 open road .
249 It gets great gas mileage .
250 Being a mother who drives a lot I wanted a safe vehicle with good gas mileage and this car delivered that and more .
251 Great gas mileage and comfortable on long trips .
252 Nice looking car and good gas mileage .
253 Good gas mileage, comfortable seating, lots of leg room .
254 The interior is roomy, the ride is smooth and solid and yet it has excellent gas mileage .
255 The gas mileage is still good, cant give specifics but for a V6, its good .
256 I had my OEM Turanzas wear out at 14K and was lucky to get local Bridgestones to gimme a mileage warranty adjustment, got new tires for $290 .
257 My mileage averages 25, but it easily gets 30 or over on the highway .

258 I get better mileage with my BMW 325i .
259 The main reason for this review is to add the broken in gas mileage .
260 The vehicle does not get as good of mileage in town as I thought .
261 The gas mileage is not what its cracked up to be .
262 The corolla is the best toyota car when it comes to gas per mileage .
263 It has excellent power and good mileage considering the amount of power it has .
264 It had hesitancy during acceleration, bursts of excessive RPMs in cruise control, and only average mileage .
265 The car has extremely dangerous hesitations and absolutely terrible gas mileage .
266 With the SW fix and using the 0W, 20 oil our gas mileage has improved from 26 to 32 mpg .
267 Gas mileage is great on this model especially the 6 .
268 Toyota may have computerized the engine and transmission to get better gas mileage but the very best I can get is 25 mpg on the highway .
269 Gas mileage is about 20 in the city, certainly not that great .
270 Overall I like the Camry for its large trunk space, sporty look, the metallic red paint, reliability and low maintenance, Toyota warranty, Toyota dealer service department and better gas mileage than my full size truck .
271 This car offers poor driver’s seat comfort, poor vision , only average ride quality, gas mileage
272 To top things off, the car gets terrible mileage .
273 Mileage has met the EPA sticker and I just started .
274 Gas mileage is only about 22 around town .
275 It gets great mileage, and runs great .
276 Mileage out of the showroom was way below advertised , but seems to have come around over time .
277 Gas mileage stinks too but it may be better if they could figure out the engine problems .
278 hesitating then surge between shifts, windshield wipers that move with power that rocks the car to the point that it feels like it will roll over, plastic parts falling off, cruise control is so unreliable I don’t use it, bad mileage, and, last but not least, half the windshild blacks out when driving at night through areas without street lights .
279 It gets great mileage for a V6, good sound system that comes standard in all Camrys and overall styling looks sporty and aggressive .
280 Gas mileage at 7500 mi is still around 20 MPG and I’m hoping it will improve as I rack up the mileage .
281 This new one gets even better mileage, averages about 33 freeway .

282 I’ve had this car for a year , bought it for the low emissions, safety, and good mileage rating , and I’m considering trading it in .
283 throttle hesitation, and poor gas mileage .
284 My previous BMW 3 series got better mileage, and believe me it was more fun to drive .
285 We have become Toyota Camry and Honda Accord lovers driving used high mileage models from 1992, 1994 .
286 The Mileage Queen has put 55,000 miles on Ricky since Sept 06 .
287 truly fantastic gas mileage .
288 Gas mileage now is in the high 20s and that should improve with time .
289 The delay in acceleration and poor mileage makes this car worse than any other car in the segment .
290 Mileage a little disappointing .
291 The gas mileage has been getting better .
292 I first averaged 23 mpg during the break in period, but ever since then the mileage have increased slowly .
293 Highway mileage is 29, which I consider poor for a 4, cylinder .
294 Gas mileage is poor, 25 mpg .
295 Highway mileage already greater than promised .
296 Appears to have good mileage .
297 Wish it delivered the gas mileage of my 2003 XLE .
298 This car has it all, styling, performance, durability, wonderful gas mileage and just a great and exciting car to drive .
299 The V6 was too much power, but with the gas mileage difference of less than 2 MPG .
300 Gas mileage is disappointing, 21 in town .
301 The mileage seems to be good too as the fuel indicator still shows approx .
302 Can’t beat the room, gas mileage and performance for dollar .
303 Good acceleration for engine size, and good mileage, especially when highway cruising around 70 mph .
304 I drove the car 600 miles in the last week and gas mileage averaged 26 mpg .
305 Gas mileage on recent long trip was a disappointing 28, 29 mpg .
306 This car has plenty of pick up and go even with the in line four cylinder engine along with good gas mileage and handling .
307 Serious disappointment in gas mileage , particularly over my previous 1999 model .
308 Gas mileage on the first tank was 30 .
309 I am a little disappointed with the mileage but I do have a tendency to drive more aggressive in the model .
310 2000 miles were on a trip north on I, 95 the rest of the mileage was in Daytona Beach, FL and surrounding area .
311 on my 2000 mile trip gas mileage in Florida, Georgia, and South Carolina was 32 .

312 7, as I edged into the mountains of NC and Virginia, the mileage fell to 30 .
313 In town driving the mileage has been 20 .
314 Would like to see better gas mileage too .
315 I am disappointed with the gas mileage .
316 It floats on the road, handles like it's heavy and substantial, but I get great gas mileage , around 30 mpg .
317 Great ride, engine, interior, gas mileage .
318 Nice gas mileage for a family car .
319 Great performance, great gas mileage , superior quality , I always thought of a Camry as just a practical family sedan .
320 I got 35 highway mileage with ac on and combined 28 29 mile per gallon with ac on .
321 I purchased this camry, three weeks ago, acceleration is a major problem, just not like the older models of camry, was in a accident, hit on the front right side, right fender, car was considered total loss, not fixable, I would not purchase another camry disappointed is this 2007 camry, gas mileage is not as good as prior years, i had to purchase another vehicle, it was not a camry, made in ky, it was a solid 2007 toyota RAV4 made in japan .
322 I would highly reccomend this car If your looking for a sporty, roomy, 4 door sedan with good gas mileage
323 Safety was #1 and mileage was #2 .
324 Traded my Highlander for it for better mileage w gas prices so high .
325 I decided on the Camry because of the value and gas mileage .
326 Biggest disapointment is gas mileage .
327 I actually get better highway mileage than sticker show .
328 I have to say the car rode great,comfortable and gas mileage great .
329 My mileage is 1 2 road and 1 2 city and I am averaging between 26, 28 mpgs .
330 I believe after it has some miles on it, the mileage will improve .
331 Gas mileage is lower than my '02 .
332 The mileage has been both street and interstate, averaging 24 miles per gallon .
333 For a 4 cylinder engine what get, up and go,not to mention the great gas mileage .
334 It is a very well designed auto and runs and handles very well, mileage not quite as good as 2004, but only have 2100 miles on it .
335 Gas mileage for us will be what it is rated, maybe a little better on highway on the flat open roads of West Texas if you don't put your foot in it all the time .
336 Comfortable and quiet with excellent gas mileage .
337 Love the looks, power, roomy interior, good mileage at 32 hwy and

25 city .
338 I like how it looked when I got the car, but with high gas prices , I am very disappointed with the gas mileage .
339 I thought great mileage & I loved the look of the new Camry .
340 If I'm going to get mileage this bad I may as well look good doing it .
341 My old 1989 Camry is still running well giving great mileage 40
342 Mileage is mediocre at an average of 25 .
343 The 4 cylinder does not get good mileage at 70 MPH plus .
344 Below it you can expect to get good mileage only if you do not have too many hills .
345 This car is easy to drive, great gas mileage and comfortable .
346 Doesn't anyone build a quiet car out there for around 30K that used regular gas and gets good gas mileage ?
347 I love the new body style and the interior is a simple pleasure except for the center dash .
348 However, there are a couple of things that kill it for me 1 terrible driver seat comfort, kills my back 2 lack luster interior design, my Acadia has much better comfort 3 the VCM drives me crazy because the constant change in cylinder use is perceptible enough to be an annoyance .
349 Love the interior and the power and speed, but not hard to beat after what I had .
350 Love the interior and exterior look, the V6 is sensational, and getting compliments on the steel metallic color as if it's a Lexus or BMW .
351 The seats are decent, the interior design is excellent IMO as well as the exterior design, and thus far it has been extremely reliable .
352 The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats .
353 The interior design was much nicer .
354 The interior is nicely equipped and I like the XM radio but not the monthly fee .
355 The new styling is very upscale, and the interior layout is also impressive and spacious inside .
356 My only reservations are the ivory cloth interior's durability had to have taffeta white !
357 nice car, add'l $$ for premium gas, not as big of interior as accord, dealer that we would utilize for service not clean .
358 I don't like the dash radio assembly, but the interior has a luxury look .
359 Only needs to add drivers seat memory, 2, tone perforated leather , xenons, rear seat interior illumination mounted under front seats, and better tilt .
360 Biggest plus I think is the roominess of the interior and the trunk .
361 The ride is very good The interior is awesome .

362 My car is taffeta white and i wish there was another interior color option other than ivory !
363 However after checking out the ’09 Camry, I was disappointed with the quality of the interior and outdated dash .
364 I like the interior space, dash, board, and a very functional cabin .
365 I have the diamond white pearl which is awesome with the tan interior .
366 Fun to drive, lots of power, smooth and a great interior .
367 The interior room is enormous .
368 The interior was boring and felt like a 5 year old design .
369 Interior very high end, exterior very upscale look .
370 Interior and exterior design is attention getting .
371 The interior is laid out great,appreciate the large screen, touch controls on the steering wheel .
372 The interior and exterior are nice .
373 Great amount of interior space, excellent design, the 190 hp engine takes off faster that I could have possibly hoped for who needs a V6 ?
374 I hate to admit that they have loud interiors .
375 The exterior and interior is more reflective of European styling and it looks amazing .
376 The interior is huge and the exterior is super sleek .
377 The interior has loud vibrating squeaking rattles coming from the glove box .
378 Still enjoy interior and exterior styling as well as overall performance and handling .
379 The interior is really noisy unless the road surface is smooth .
380 Yes, it is roomy, has a nice interior, silky smooth engine, good transmission and direct steering .
381 From the hard and uncomfortable driver seat, excessive body roll, several rattles in the interior and intrusive road noise, the vehicle just does not strike a chord n .
382 The Accord’s interior look and feel great .
383 Interior is superb, exterior is very stylish .
384 The new body style looks great, and the interior is laid out very well .
385 User friendly interior design .
386 I got the dark blue Accord with simonize paint and interior .
387 The car has a 268 hp engine which provides plenty of power for passing and yet the car gets 31 to 33 mpg the interior of the car is well laid out and the controls and gauges are easy to read and handle the fit and finish of the car is flawless a well built car the exterior design is smooth and flowing well done without excessive curves and as usual the Honda reliability remains its strong point I love driving this car I hate to get out of it at days end this is the first Honda I’ ve purchased ill never drive anything other than a Honda again

388 Excellent pickup and great interior .
389 Most of the interior layout has been carefully thought out .
390 , > Impressed by the headlamps and the interior layout .
391 The black leather seats feel a bit hot on the back in the warm weather but otherwise no complaints about the interior .
392 The interior design is roomy and very comfortable .
393 Interior is very roomy, and I can sit comfortably in the rear seat at 6’2 .
394 Good trunk space, nice finish and materials in both the interior and exterior .
395 Solid build, comfortable interior, smooth ride, fuel efficient averaging 27 .
396 The interior and exterior are nice .
397 I previously owned a Chrysler 300 2006, so it is difficult going from a real comfortable interior, really massive dash to a bland and old fashioned interior .
398 Great interior room, Great safety features, and a great deal .
399 Everything is extremely well engineered and designed from the interior to the exterior to the engine compartment, etc .
400 Nicer interior than the Mercedes C300’s we looked at .
401 I completely disagree with experts saying that the new Honda Accord’s interior is of good quality .
402 Handles great, awesome fresh interior, lots of cool new features .
403 I love the amount of interior room of this car .
404 Great ride , roomy interior, legendary Honda reliability .
405 Eye, catching appeal fit and finish exterior interior safety features laudable audio system good esp w XM radio interior room spacious 3 .
406 Finally in November the dealer traded for a car just like the one I wanted except it had a different color interior .
407 Awesome interior with great comfort .
408 The new body styling is a big plus and the interior has the look of a more expensive vehicle .
409 The interior is tight and well put together .
410 High Honda quality interior materials, great stereo, and loaded with every option you could think of .
411 The interior is luxurious and large .
412 Interior is nice but not as comfortable as past Accords and feels a little cheap .
413 I am extremely satisfied after the first week though it was more costly, I still like the smooth power and handling of the V, 6, the comfort of the leather interior, and something new for me .
414 The interior design and the performance of the V6 are the highlights .
415 The interior room is plentiful .
416 Almost the entire interior of the car can be controlled by voice

commands such as temp .
417 Black leather interior is very classy and plastic trim is nice .
418 The interior is plenty spacious and once I mastered all the controls and settings, they were easy enough to operate .
419 The interior is very similar to that of the TL, but for about $7k less .
420 I did not like the interior door moldings that covered the door controls .
421 Wish the colors were better with matched with the interior and exterior colors offered .
422 From the overall exterior styling, the leather interior, dashboard, moon roof, engine, wheels, tires, and even the trunk you get nothing less than quality .
423 The interior is comfortable, neat and you can find everything within reach .
424 The interior is roomy, exterior is definitely better than BMW 3 series .
425 Although it's a lower trim level, it has high quality interior trim very comfortable seats and and very smooth, quiet ride .
426 The interior and exterior look great !
427 I love the interior layout and comfort .
428 First of all, the interior has way too many cheap plastic parts like the cheap plastic center piece that houses the clock .
429 3 blown struts at 30,000 miles, interior trim coming loose and rattling squeaking, stains on paint, and bug splats taking paint off, premature uneven brake wear, on 3rd windshield .
430 Insanely cheap plastic all over interior .
431 Disappointed in interior and exterior quality .
432 I love the color of the exterior and interior .
433 This car is nearly perfect when compared to other cars in this class regarding interior dimensions, visibility, exterior styling, etc .
434 Several parts in the interior rattle including the sunroof and some parts of the dash, the radio randomly will eject CDs, etc .
435 The interior is roomy, the ride is smooth and solid and yet it has excellent gas mileage .
436 The interior looks good but feels cheap compared to my 1997 LE camry .
437 The interior is large, the controls are well placed and simple .
438 Interior noise level is unacceptable , this is one noisy car on the freeway .
439 I love the exterior, but the interior is nothing to brag about .
440 The interior could use some work to make it not so cheap and plastic looking .
441 The biggest complaints are the softness of the seat, the super cheap interior dash plastic and the location of the door pulls

, they render the door arm rests useless .
442 The interior looks great to me .
443 This interior is as good or better than others in it’s class .
444 The interior is stylish, roomy and has many nice features .
445 5 Poor craftsmanship on interior .
446 Cheapened interior materials, flimsy steering wheel switch gear, less padding in seats, only a 2, way power passenger seat, plastic covered board for seat, back map pockets, baby, puke yellow fake wood trim, etc .
447 , all combine to paint a less than luxerious interior .
448 Only thing would like to see is that the interior be made more available in the darker in the SE .
449 I love everything about my Camry, except for the interior looks, very cheap and the non alloy rims are very cheesy or cheap .
450 The car also does not allow fresh air through the vents if the AC isn’t on, the interior becomes very warm, very quickly .
451 Looks are great and interior is comfortable, but it ?
452 Even the interior has not held up along with the awful wind noise at highway speeds .
453 The controls were installed without a problem no cutting of interior plastic, the knee airbag was bypassed .
454 Interior looks OK but is built a little cheap .
455 The interior is so very quiet, you must compare this car to a Cadillac .
456 The interior is very luxurious and comfortable, however the car feels slower than my 2002 Camry LE .
457 I like the looks and interior but as described in some of the other reviews it has a hesitation problem when you slow down or brake, and then get back on the throttle .
458 Also, the sound system is so poor unless you are willing to spend $3K more to get the JBL and leather interior, which come together .
459 Interior quality is very poor .
460 Fit and finish are exquisite, the interior is extremely well designed, looks good, fun to drive .
461 Sound system is excellent and interior was adequate but the room is awesome !
462 The interior feels that of a Lexus or BMW and the exterior is an eye catcher .
463 I love its Avalon like roomy interior and great looks .
464 I love the interior lighting .
465 The exterior and interior are nice .
466 Like the looks and styling, both interior and exterior .
467 Interior exterior quality is very good .
468 3 It is a good interior and exterior design and should be copied by other car makers, but the MPG for the 2 .
469 Very low interior noise level, which adds to the long trip comfort .

470 The styling does not say Camry anymore and the interior is mostly excellent , door handles are too hard and plasticky, some rattles especially when cold outside, not overly fond of the center console design .
471 The Camry has a ton of style and lots of interior room without being to bulky on the outside .
472 It serves the purpose in which I bought it, and I really do like the roomy interior and the new styling, but there really is no fun factor to it .
473 Horrible quality of interior .
474 After driving it a few days, the interior squeaking and rubbing noises increased so much that I drove to Toyota and had the body shop manager check to see if it had been in a major accident .
475 The interior is very roomy and spacious and Toyota has given some nice standard features in LE .
476 The interior design is excellent   .
477 Interior is very nice and quiet .
478 Very comfortable, quiet interior .
479 New interior is very pleasing to the eye and am happy to have features like tire pressure indicator, side airbags, 4 wheel disc brakes and 16 inch wheels included as standard .
480 Feels expensive, yet comfortable with larger interior than my Grand Prix .
481 I love the body style and the interior .
482 Exterior reminds me of a 530i and the interior is plush especially with the light woodgrain finish .
483 The interior is on par with other cars in its class, but not up to the fit and finish of previous Camrys   .
484 Examples include fit and finish had to have the drivers door realigned due to metal, to, metal contact causing terrible rattling , poor fit of interior parts, which causes a lot of rattling, especially when it’s cold out the auto tranny has a history of serious problems and acts weird, and lastly the paint quality, which chips very easily .
485 The interior is top notch and the navigation system is very intuitive .
486 Customizable features which don’t require dealer help like some brands auto lock modes, interior light modes, etc .
487 Interior is simple and well laid out .
488 The blue neon center console makes the interior look really cool, every single person that’s been in my car loved it .
489 The interior is extremely comfortable, and spacious .
490 I love the lighting on the radio controls, and the material on the interior, very soft and stylish .
491 Interior is very nice and much improved .
492 Practicality, good interior space, easy to get in and out of including putting an infant in a car seat .

493 Interior materials are far better than my old Mazda and V6 power is nuts .
494 I get positive comments each day on the exterior interior design .
495 I bought this car smitten by its exterior look and interior comfort .
496 The interior is classy, the standard MP3 is useful, the host of curtain bags and standard features add to the plus .
497 The new design is very aggressive on Toyota’s part and the interior design is very contemporary .
498 The ride is quieter, the car faster, the exterior and interior looks better .
499 The interior is nice and roomy and the exterior design is beautiful .
500 Great ride, engine, interior, gas mileage .
501 It shifts hard, has a lot of play in steering, has quite a few blind spots & the interior is cheap plastic which scratches very easy .
502 The sunroof actually comes down and slides between the exterior and interior thus minmizing wind noise at speed .
503 The leather interior is worth the money .
504 Luxurious interior, great MP3 player addition .
505 The interior is fairly pleasant but suffers from too much hard plastic and some poor fits !
506 The interior is very quiet at highway speeds .
507 The cloth interior is great and the 4 cylinder has tons of power for such a small engine .
508 On top of that some interior trim pieces didn’t match and one fell off !
509 Smooth and responsive interior is as luxurious as you can get without slapping an L on the grill .
510 The first one was returned to the dealer, on the day of delivery, because of excessive rattling noises coming from the interior , especially the back right side of the car .
511 The ride is refined, steering is tight, plenty of interior space, the exterior design is refreshing to look at .
512 My only complaint with the interior is the color of the fake wood :
513 The interior is much more comfortable than my last 3 Camrys and the exterior styling is oh so chic .
514 It’s quiet, get good gas mileage and looks clean inside and out .
515 The mileage is great, and I’ve had to get used to stopping less for gas .
516 Thought gas mileage would be better .
517 There are trade offs that I have no problems with, my mileage after two tanks with mostly city driving is 21 but acceleration is very good, smooth, ride a little firm but enjoy the handling .

518 I chose it for the low emissions, value for the money, reliability and gas mileage .
519 The EPA mileage ratings and what the dealer bragged about mileage wise are a joke .
520 6, 4, 3 eco engine has poor performance and gas mileage of 22 highway .
521 road noise is horrible, stereo sucks, terrible gas mileage etc .
522 Otherwise the gas mileage, service intervals, drive and dependability is still pristine .
523 I traded an 05 Acura TL for the gas mileage savings .
524 Runs better than AUDI A6 , Better Mileage
525 Gas mileage at first wasn't great but having reached 2500 miles, it seemed to go up dramatically in city driving .
526 Leased in Feb 2008 as a replacement to a Pilot, which had poor gas mileage .
527 I do miss the carry and load capacity of the Pilot, but the Accord gets decent gas mileage by comparison .
528 My old Buicks had far smoother shifts at far higher mileage .
529 It has excellent gas mileage drove from PHX to San on a half a gas of tank .
530 gas mileage sucks, i was getting 20 mpg on 05 accord v6 and seem to pull only 18 mpg on this one .
531 Gas mileage is only 20 around town and 26 to 27 on the highway with a four !
532 The car has met expectations, aside from the gas mileage and wind noise .
533 Almost half the mileage as compared to advertisement .
534 At first the Gas mileage was very poor but has really improved .
535 I wanted an inexpensive car with good mileage, and strong resale .
536 Very good mileage, getting about 28 mpg combined highway, and I have a heavy foot .
537 The 190 hp I4 engine is powerful and smooth enough to enjoy, without sacrificing fuel mileage .
538 great mileage, poor build quality of the car .
539 On top of all this, I get horrible gas mileage in city driving I get 15, 16 mpg .
540 It gets great gas mileage and love the car .
541 Mileage over three tanks has been 25 .
542 3 mpg as consistent full tank highway mileage .
543 The car drives great and gets better gas mileage than my 2000 Lincoln LS V8 .
544 It looks great, handles well, and gets good gas mileage .
545 The gas mileage has improved from 18MPG to 21 but that still is not good .
546 Gas mileage has been a bit disappointing, but it has been improving .
547 the variable cylinder management changes to 4 cyl when not under

load, this helps with fuel mileage .
548 After owning a Honda Accord EX I had to go back to the Honda the gas mileage can’t be beat .
549 Gas mileage is around 22, 23 in town and 29, 30 on the highway .
550 Fuel mileage has been less than expected .
551 It’s no 8 cylinder GT, but it also gets double the gas mileage and so far, no problems .
552 Aside from missing the turbo’s acceleration, I’ve preferred the Accord’s better mileage, handling and comfort .
553 The manual transmission lets me control the car better and achieve higher mileage .
554 So beware, if you are trading in your V8 for a mileage vehicle, this is not it in my case .
555 The car is getting great gas mileage even though I have only been driving it 2 weeks .
556 Our 2008 Accord is very disappointing, our in town mileage is 14 .
557 Gets great gas mileage, I mostly drive city and I am currently receiving 25 .
558 I just love the VCM makes the car give great mileage .
559 Initial gas mileage looks good too .
560 Don’t buy this car if you want good gas mileage .
561 I have a V, 6 with Variable Cylinder Management which is supposed to let the car run on 3, 4 or 6 cylinders, as needed, to improve mileage .
562 My BMW 530i got better mileage .
563 It is fun to drive, I love the color, it has great features, the sound system is nice, the power is perfect and the gas mileage is great !
564 Fun to drive, fairly roomy, looks good, gas mileage is OK , but not as good as Honda advertises .
565 Gas mileage is wonderful, 1st tank 26 mpg with almost all city driving .
566 I had tons of room in my 4Runner, but I needed something that would get better gas mileage w o giving up power .
567 I am so very disappointed with the gas mileage !
568 I traded for better mileage, and this is what I got .
569 I will warn you though, that if you drive it like it should be driven, gas mileage isn’t the best .
570 It feels safe, performs well, looks fantastic and gets decent gas mileage for its size .
571 The Accord is better than other those car on gas mileage and reliability .
572 Strangely, the gas mileage is not as good as the Acura but is acceptable .
573 Some reviewers were complaining about gas mileage .
574 Gas mileage is horrible too, 20 mpg city highway after 6000 miles .

575 If you are looking for a car that is affordable and well built this is the car for you bad gas mileage
576 In reality we have been very disappointed our in city mileage is 16, 17 and highway is better at 27 .
577 While the mileage is not bad it good be better, but as the acceleration is good for a 4 cylinder it's a trade, off .
578 I am sure as gas prices go up cars will be built to get better mileage at the expense of acceleration .
579 Good looking inside and out, comfortable and roomy, commendable performance, and excellent gas mileage .
580 I live in Chicago and drive downtown and back 2 times a week for school and am getting great mileage .
581 Only update is after about 5k miles the fuel mileage is less than I had anticipated .
582 Everything else such gas mileage, handling, stereo system is fine but it doesn't make up for the loud rattles and wind noise .
583 It's almost embarrassing driving such a nice car around a parking lot and have it sound like a high mileage beater .
584 So I saved $2 K upfront and will also save down the road since the 4 cylinder gets slightly better gas mileage .
585 It is a well built car that runs smooth and gets great gas mileage .
586 Gas mileage is still getting better though .
587 The gas mileage on the highway is about the same for both models .
588 Local mileage with the '08 has been about 24 mpg, and about 25 mpg with the '06's that we've leased .
589 I decided to go back to Honda as even with high mileage they keep their value .
590 Mileage , also not impressive , all I can get is about 24mpg, far from the 32 mpg you see on the window sticker .
591 Posted mileage ratings are for those who have a heavy right foot .
592 Gas mileage is fantastic especially going from a V8 SUV to a 4 cylinder sedan .
593 I was tempted to go for the V6, but I drive 42 miles one way to work and we have an '07 Odyssey with the variable cylinder management system and unless you're on long highway runs it doesn't get the gas mileage Honda claims .
594 I just love this car , and with almost double the highway gas mileage that I was getting with my Grand Cherokee , that adds a lot of $$ towards my monthly payment .
595 190 hp and superior gas mileage .
596 It wasn't worth saving the little difference in gas mileage for this Honda .
597 The gas mileage is about 45 to the gallon going on the highway with cruise at about 800 or 900 RPM and about 38 going 70 .
598 The Gas mileage is good, the acceleration sometime is slow when

cold from 1st to 2nd gear .
599 I hope to get better mileage on extended highway trips .
600 I think the mileage would be even better with a 6 speed stick shift to drop the tachometer from ˜2300 rpm to <2000 rpm at 60 mph .
601 Gas mileage has been improving and is now consistently 29 hwy 22 city .
602 Very peppy engine great fuel mileage 28, 30 combined .
603 I am not known to drive slowly so I am pleased with the mileage .
604 We bought this car with the expectations of getting a car that feels good with my bad back, gets good gas mileage, and is reliable .
605 So far, the reliability has been as expected, it is comfortable on my back, and the gas mileage has been pretty good .
606 It is great to drive, has many nice features and gets you there with great mileage .
607 Mileage is very good and we have already taken it on a long trip .
608 I had rather not have it and sacrifice the mileage .
609 The gas mileage has been as advertised, hitting 32 mpg on the highway when driving at 65 MPH .
610 Gas mileage after 1000 miles is averaging apprx 23, 24 mpg in a blend of city highway .
611 It has everything but good gas mileage .
612 This car has great gas mileage even with the V6 .
613 The best gas mileage I can get is 22 mpg which is mostly highway and the car sometimes hesitates during acceleration
614 I drive around 60 miles a day so fuel mileage was important .
615 First tank mileage was 27 mpg not bad at all .
616 highway mileage slightly over 30 as advertised .
617 with gas prices, wanted better mileage .
618 It gets good mileage on HWY = 30 but mediocre on local = 21 .
619 SUV, wanted something with better gas mileage and something that had good resale value .
620 The 4, door provides the room we needed, the exterior design keeps the sedan from looking boring, the gas mileage is great, the price point was right, and the reliability is terrific .
621 Gas mileage is disappointed, avg 20 mpg so far .
622 i just purchased my lx, p a couple of weeks ago, having driven a pick up for the last 25 years, i was really surprised at how much i like this car, going from a big v, 8 to a 4 is a change but the power is good, gas mileage is great .
623 At first the gas mileage was a disappointment, but as the car is now breaking in it’s getting better .
624 I test the car and was very impressed with the looks and the 4cyl was adequate since gas mileage was very important to me .
625 I expected a little better gas mileage avg, approx 26 mpg .

626 poor gas mileage look close at your window sticker not the big mpg numbers but the ratings below, it tells you that you could get 17 mpg based on your driving habits .
627 The ride is excellent, and the fuel mileage is impressive so far .
628 Wanted something with better handling and gas mileage .
629 Great gas mileage for a v, 6 .
630 Gas mileage is horrible on highway at 21 mpg .
631 My mileage, is averaging about 28 .
632 I was a bit disappointed with the 4 Cyl mileage as I drive over a 100 miles a day round trip to work .
633 There seems to be no way to shut it off and mileage is about 26 27 highway .
634 Mileage jumps on the highway to 31 32 at normal speeds .
635 The car is very smooth for a v4, my first, but I thought that the gas mileage should be More about 38, 45 .
636 Around town gas mileage is not as good at 22 with a mix of city and high way .
637 Very happy with my 08 Accord, performance is quite adequate it has nice looks and is a great long, distance cruiser .
638 6, 4, 3 eco engine has poor performance and gas mileage of 22 highway .
639 Overall performance is good but comfort level is poor .
640 I’m impressed with the performance as well as efficiency gains .
641 It has room, performance, good MPG for its size and excellent reliability .
642 For the record I test, drove the Lexus350 the BMW 5 series, the infiniti G35 and enjoyed the Honda performance equally for far less money !
643 Very happy with the car enjoy the ride and performance .
644 The performance of the engine is very smooth .
645 This car had rattles at 500 miles and has horrible performance even for a four cylinder .
646 Great performance and handling make this a real Winner !
647 Engine performance lacks punch after 60, head rest are poor design, lacks driver seat memory rear seat a c, radio system is marginal compared to Bose, Seats are hard and small for a large person .
648 There seem to be so many components that enter into the VCM that performance can vary WIDELY from car to car .
649 Features, quality, reliability, and performance, at a price no other car maker can touch .
650 190 HP engine is a good compromise for performance and fuel economy .
651 I owned this car for only a week, but I am pleasantly surprised by its performance and build quality .
652 This car lacks the performance and handling of previous years .
653 Good looking inside and out, comfortable and roomy, commendable

performance, and excellent gas mileage .
654 Still enjoy interior and exterior styling as well as overall performance and handling .
655 I just put it on the highway this weekend and its performance was amazing !
656 The bigger size has taken some getting used to, but the additional horsepower compared to the ’02 and the performance are like night and day .
657 It fits right , is fun to drive, great stereo, fuel economy, performance .
658 If you want sports sedan handling and performance, then pay much more and buy a true sports sedan !
659 I went for comfort over performance to fit it in my budget so the EX, L with the 4 cyl engine .
660 I researched many other makes and models but for the performance, quality, and style, the accord won hands down for cars under $32,000 .
661 Performance is outstanding, more like a sports car than a coupe .
662 Lots of power with the 6 spd, and the car has a great balance of style, performance, and reliability .
663 No problem with quality, performance, etc .
664 Engine performance is very lacking .
665 t anywhere close to 3 series on many facets, namely performance, but sadly to say, in others, it surpasses .
666 The 4 cylinder lacks performance and handling and the gas saving is only minimal .
667 The car is great, both with styling and performance .
668 I purchased a 2004 V6, Leather and I did not think Honda could do any better with design or performance .
669 I love the styling the performance and handling .
670 I was looking for a luxury, feel car with great performance at a good price .
671 Overweight , 3600 pounds, lots of road noise, and the combined performance of the VCM and the grade logic automatic transmission mke this a miserable driver .
672 The interior design and the performance of the V6 are the highlights .
673 I was looking for a mid size coupe with style, performance and all season traction capability .
674 Styling in and out is fantastic, and the v, 6 performance is all one would hope for and more .
675 It does not diminish the performance of the car, it is just annoying .
676 After tracking almost 2 months of research on American and Japanese mid, size car models, only two stands out for their performance, reliability and safety , Honda Accord and Toyota Camry .
677 I previously owned a Toyota 4Runner which had incredible build

quality and reliability .
678 I bought the Camry because of Toyota reliability and quality .
679 I purchased a 2007 Camry because of the looks of the redesigned model and because of the legendary Toyota quality and reliability .
680 As of today, I am a bit disappointed in the build quality of the car .
681 Disappointed in interior and exterior quality .
682 Toyota did a great job with design but forgot about quality !
683 This car needs quality improvement !
684 The fit and finish in the cabin is not the level of quality I expected .
685 This car looks great and the build quality is good .
686 I am so disappointed in the quality .
687 I've had 2 Camry's before the one, and bought it thinking that the quality standards known to a Toyota would still remain excellent .
688 It's now apparent that Toyota quality took a nose dive .
689 Mine suffers from the tranny slip on the 3, 4 upshift when cold , build quality is good but nothing like the Toyota, hype I was expecting, as it has its share of squeaks and rattles just like a 10 year old Chevy .
690 Overall a good car, no build quality issues yet .
691 After owning a 95 Camry, I expected the same quality .
692 The quality of construction, ride, quietness, and legroom are excellent .
693 A lot of defects that I still do not understand how my car passed the quality inspection when it was manufactured .
694 This car offers poor driver's seat comfort, poor vision , only average ride quality, gas mileage
695 JBL radio is low quality cd, fm, and mp3 all sound the same .
696 It has high quality amazing ride and the fit and finish is great .
697 However, the quality of this car is not acceptable for Toyota standards .
698 Initial quality was lacking and it's only getting worse .
699 This is our 6th Toyota and we continue to receive the quality we expect .
700 s not worth buying given the quality issues .
701 Seems the company's quest to be #1 has caused quality issues .
702 Interior quality is very poor .
703 This was the 7th Camry and the last, I feel Toyota quality is slipping big time .
704 This is not the Toyota quality I was expecting .
705 Interior exterior quality is very good .
706 Overall build quality very good .
707 Replaced speakers with Sony speakers, sound quality improved .
708 The ride, comfort, and drive is as expected, however, the quality

and reputation of yore are completely gone for the flagship Camry .
709 It’s not a terrible car by any means, but the quality since they starting building them in America has really slipped .
710 Horrible quality of interior .
711 Some have mentioned disappointing build quality .
712 As compared to my wife’s 2004 Highlander, my new Camry does not exhibit the same build quality .
713 While I applaud the new design , Toyota seems to be slipping in quality .
714 Examples include fit and finish had to have the drivers door realigned due to metal, to, metal contact causing terrible rattling , poor fit of interior parts, which causes a lot of rattling, especially when it’s cold out the auto tranny has a history of serious problems and acts weird, and lastly the paint quality, which chips very easily .
715 The ride, the fit and the build quality are what I was expecting after owning Toyotas in the past .
716 This 2007 is the epitome of the Toyota’s quality .
717 I also am not impressed with the quality .
718 The sound quality is excellent and answering or dialing a call couldn’t be easier .
719 Solid, high quality, comfortable and quiet .
720 Depends on gas quality & wind conditions .
721 The fit and finish quality is poor .
722 Toyota’s quality is slipping .
723 I paid for quality & all I’ve gotten thus far is NOT quality .
724 I drive quality cars and I can attest to the fact this car rides as well as some cars costing considerably more .
725 It is a pleasure to drive and it has Toyota quality written all over it .
726 Great performance, great gas mileage , superior quality , I always thought of a Camry as just a practical family sedan .
727 Quality of assembly is outstanding .
728 Toyota has this supposed impecable quality .
729 So far the quality appears to be strong, as expected .
730 High quality inside outside finish
731 The quality of the leather seats appears to be very good .
732 My third Camry and by far the worst, the paint is of poor quality .
733 Some quality issues with fit and finish .
734 I have rattles on both B pillars and the build quality is rather poor, with unsightly gaps in the passenger side dash where it does not fit together properly .
735 Front seats are very uncomfortable .
736 No memory seats, no trip computer, can only display outside temp with trip odometer .
737 needs power seats on the passenger side .

738 I haven’t had any back pain from the seats, maybe these people exceed the seat weight limit ?
739 There is a great deal of road noise in the cabin and the seats are very low quality .
740 Power seats are not fully adjustable .
741 Front seats are too narrow and not deep enough .
742 The seats are extremely uncomfortable .
743 I previously owned a 98 Avalon, and found the seats more comfortable than the Honda .
744 The seats in the Honda are more firm .
745 I’m very sad , I loved my daughter’s Civic and the dealer service is fantastic, but even good service can’t help the uncomfortable seats .
746 It cost me thousands of dollars to get rid of it, but the seats gave me and my wife back pain after 20 minutes of driving !
747 Although it is fun to drive and quality seems ok, the leather seats are very uncomfortable, especially on a long drive .
748 The seats are decent, the interior design is excellent IMO as well as the exterior design, and thus far it has been extremely reliable .
749 In fact, I love the car just wish Honda wouldn’t have made such horrible seats .
750 Body wasn’t used to seats like if you bought a new mattress .
751 The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats .
752 I just purchased an Accord Sedan with leather seats .
753 Only needs to add drivers seat memory, 2, tone perforated leather , xenons, rear seat interior illumination mounted under front seats, and better tilt .
754 I can also fit three car seats in the back which was the reason I was able to go back the the Honda family .
755 The seats are very comfortable & supportive .
756 I test drove an EX, L and felt the seats were too firm plus, the EX, L seemed too slow .
757 This Accord has more road noise than I like and the seats tend to be hard, unlike my other Accords .
758 Engine performance lacks punch after 60, head rest are poor design, lacks driver seat memory rear seat a c, radio system is marginal compared to Bose, Seats are hard and small for a large person .
759 The seats are comfortable, and there is ample leg room in the front and rear .
760 Most uncomfortable seats in any vehicle I have ever owned .
761 Only 2 things could make it better memory seats and a smoother shifting transmission .
762 Seats are firm but not uncomfortable , very BMW like .
763 Advise anyone considering the L to drive one for awhile if you can , some cannot stand the seats .

764 The seat cover was coming out in between the seats .
765 The only for sure complaint I have is the seats seems to hurt my back after I drove for a period of time, this may be because I am use to my silverado truck with leather bucket seats .
766 DON'T rely on your test drive, the seats are Very uncomfortable and when the engine goes into the econo mode the vehicle shifts rocks violently forward and when leaving the econo mode it shifts rocks forward once again which means that the vehicle is CONTINUOUSLY SHAKING AND ROCKING .
767 Seats are very comfortable and ride is very smooth !
768 It's a black beauty with comfy leather seats .
769 The front seats are extremely uncomfortable after anything more than 15 minutes of driving due to what I see as a design flaw, the seat curvature is too great, and even with the lumbar support all the way retracted, it still feels like there is some type of bar sticking out in the wrong part of my back .
770 However, long, distance comfort is poor due to hard, narrow and deeply, bucketed seats combined with a very taut suspension which transmits even minor road imperfections through the whole vehicle .
771 At first the seats seemed stiffer than I'd like, but after making a 2 1 2 hour trip, It felt very comfortable once I got the seat and lumbar adjusted to my liking .
772 Great leg room in the back and the seats a very supportive .
773 Door closure is solid, leather seats are very comfortable .
774 Ride is very good, but seats are just a little firm .
775 Seats are not very comfortable and not happy with the heated seats .
776 The seats are very comfortable and I love the cloth .
777 Seats are little on the hard side .
778 The black leather seats feel a bit hot on the back in the warm weather but otherwise no complaints about the interior .
779 Steering nice and tight, seats a little stiff but comfortable .
780 We wanted three things, heated seats and mirrors and an easy to get out of back seat for some aging friends .
781 Ride is superior, comfortable seats, radio excellent .
782 5 Seats= Like sitting on a church pew .
783 Leather seats are the only thing of good quality .
784 Problems with steering wheel, windows & seals, seats .
785 Smooth responsive acceleration,top of the line high quality supple comfy leather seats .
786 Also, amazing leg space in front AND back seats , the Accord could almost be considered a full size sedan .
787 5L V6 scoots sporty handling and acceleration good sporty leather seats highway gas mileage appearance package worth having no dealer service yet Negatives :
788 First off the new body style is very appealing and the new seats are more forgiving for larger men .

789 The heated seats for me and my passenger are a plus for the cold weather .
790 hard seats, hard ride, more road noise than expected, disappointing gas mileage .
791 The seats are supportive and the materials are great .
792 You get a V, 6, heated leather seats, XM, 18 rims .
793 Cloth front seats big & comfortable .
794 After slowing down, transmission has to be kicked to speed up .
795 I wonder if the people who have problems with rattles and transmission were built in the US .
796 The transmission, I don't know what to tell you, but good luck if you don't learn from my mistake .
797 I did not notice any hesitation with the transmission until after I read about it last summer, and now I sense a slight bit occasionally .
798 I've had the same transmission problems hesitation issues as everyone else .
799 I immediately starting noticing transmission surge during 2nd and 3rd gear during first few minutes of driving .
800 The transmission is horrible, it shifts revs horribly at the wrong times, it putters when it hits 1 1 2 rpms while coasting unless you rev it or hit the breaks, if you try to start the car in really cold weather it makes a horrible grinding noise, the dash rattles ALL the time, when I try to accelerate getting on the freeway it doesnt move & scares me and when it does move it revs even after take your foot from the gas .
801 The transmission doesn't shift correctly, and it has almost caused me to get into an accident twice .
802 I'm pretty content with pretty much everything the car offers except the common issue of the transmission that doesn't want to seem to work when you need it .
803 Unlike the common concerns with the transmission, all of my concerns problems are with everything other than the drivetrain .
804 decent power for a 4 cylinder, but a dangerous hesitating transmission that toyota does not seem to want acknowledge or fix .
805 My Camry has been in the shop four times for the transmission problem and still has not been fixed .
806 First thing that come to me off the top of my head is the transmission .
807 The transmission is the worst ever for camry .
808 However, there are too many problems with the transmission .
809 I have the 4 cylinder with manual transmission .
810 I've had no significant transmission problems .
811 Transmission is terrible , , acceleration lag is a safety issue .
812 Transmission also can't decide what gear it wants to be in .

813 Transmission was replaced by Toyota in the first year .
814 The transmission feels terrible when it shifts .
815 The transmission is crap, and erratically shifts despite modest acceleration and conservative driving habits .
816 The transmission shifts smooth at all speeds .
817 No sign of the transmission problem people have complained about, but I'm not expecting a Porsche .
818 No rattles or transmission problems .
819 After driving my car almost 20,000 miles I have grown disappointed with the transmission hesitation problem as it did not show during the test drive .
820 Had 2 TSBs done to recalibrate engine, transmission .
821 The engine and transmission works flawlessly when a particular brand of fuel is used and I am absolutely sure I am correct .
822 I have the transmission problem .
823 No transmission problems as reported by so many others .
824 The engine transmission was a Jekyll Hyde affair .
825 Here are the transmission problems I've experienced :
826 Transmission is confused and CONTINUALLY shifts at speeds of 28 to 35, 38 to 42, and 45 to 51 MPH .
827 At this rate, the Transmission will go out @ 37,000 miles right after my Warranty expires !
828 Obviously they moved the costs around to provide for the new higher power V6 and the 6 speed transmission, which are so far the car's only redeeming features !
829 Toyota now has a fix for the accelerator hesitation and transmission problem !
830 EG7031 recalibrate ECM engine and transmission 9159 Bulletin # EG036, 07 .
831 I'm not sure what everyone talks about with hesitation transmission not enough power ?
832 The transmission cant make up its mind it hesitates to shift .
833 Transmission sticks in fourth gear and rpm surge while using the cruise control .
834 I am not having all the other issues everyone else is, not sure if its because mine is a manual transmission but I can't say how much I love it .
835 Toyota may have computerized the engine and transmission to get better gas mileage but the very best I can get is 25 mpg on the highway .
836 While in cruise control and going up a slight incline the transmission is constantly shifting and the rpm goes up and down by as much as 1500 rpm .
837 While driving on a straight and level road at about 40 mph the transmission is changing gears .
838 Loved the car but two transmissions failed within 19000 miles before I got rid of the car .

839 The transmission design has major problems and so did the replacement .
840 My dealer told me the new transmissions were on back order and couldn’t even give me an ETA .
841 The side front windows limit visibility, the transmission hesitates when shifting, the back seat passenger room is spacious, the stereo system has a great bass and the versatility of CD changer, satellite, iPod, etc .
842 My transmission works perfectly fine, is fun to shift but does better on its own .
843 below the advertised numbers, and a jerky, balky, surging transmission that is difficult to use .
844 Terrible transmission that doesn’t shift right .
845 the significant transmission hesitations are unacceptable and possibly unsafe, and the 4 cyl engine provides inadequate power when challenged .
846 I feel the plusses outweigh the negatives, but any prospective buyer should take a serious test drive under varying conditions and actually experience transmission hesitations and the mediocre acceleration performance .
847 After one week, I found a rusted conjunction block, which mounts the transmission .
848 BTW, this is an auto transmission .
849 I hate the transmission as it always hesitates to downshift when the power and speed is needed .
850 No problems with the transmission at all .
851 I have had no transmission issues or rattling, the comfort and ride of this vehicle felt to me much more high end then what I had paid .
852 There have also been a few isolated incidences where I have noticed a delayed surge in the transmission, which once put me in a potentially dangerous situation .
853 No transmission flares, hesitations, rattles or any other problems .
854 I had one for a year, Toyota was good to replace the two transmissions that failed, I was on my 3rd tranny, when my engine light came on due to a sensor in the tranny .
855 The gas pedal & transmission are out of sync .
856 At lower speeds when you try to give it gas an intermittent delay occurs between the gas pedal & transmission .
857 Acceleration or transmission shifting :
858 Quiet and refined ride, 4 cyl has sufficient power for everyday driving, and a smooth transmission that shifts well .
859 Transmission not nearly as smooth as previous 4 speed .
860 The transmission does occasionally get confused and takes a while to select the right ratio, but this does not occur frequently .
861 The transmission is weak, you need to think twice before jumping

into traffic .
862 Obviously since I got the manual transmission I haven't had any problems with acceleration or anything like that .
863 Transmission has a very strange hesitation when shifting .
864 Performance stinks due to transmission, always looking for another gear, constantly jerking, dash lights always dimming, lower grill always slipping out .
865 When we returned home, I took the car to a transmission specialist and found out that the transmission is slipping .
866 Rattles, squeaking, and transmission troubles started shortly after .
867 I wanted a larger car that was comfortable and the redesign of the Accord making it bigger made the difference .
868 The car is VERY comfortable and the air conditioning is perfect for the heat here in Arizona .
869 It's VERY bothersome when the transmission down shifts the second one brakes when going down a mountain .
870 The speed control as well is balky in that the slightest uphill grade causes the transmission to down shift .
871 The accelerating is great, the transmission is smooth, it handles well and breaking is excellent .
872 I loved my '05 Camry 4 cyl automatic transmission LE, but I hate my '07 Camry 4 cyl automatic transmission LE .
873 Many people have mentioned a hesitation in the transmission I haven't seen it .
874 Ash leather interior with light yellow fake wood trim is just ok design .
875 After researching on the internet I found that the computer for the transmission needed reprogrammed .
876 No transmission problems, reacts instantaneously .
877 However, the transmission is a little confused at times during downshifting .
878 This is my second Camry and I like it, especially the art decoish design and simplicity of interior controls .
879 I have had issues with the new 6 speed transmission, there is a shift flare between 3rd and 4th gear with my car .
880 Toyota is aware of the problem and they are actually replacing my transmission since they cannot figure out what the cause is .
881 Hopefully once I get a new transmission, it will be OK .
882 The combination of the weak engine at low engine speeds and the transmission hesitation is so bad that the car is, in my opinion, a safety hazard .
883 Dealer recalibrated ECU, engine and transmission .
884 Test drove identical camry at a different dealer transmission reacts same way .
885 Transmission slips, especially when the car is cold .
886 Transmission replacement did not resolve the problem .

887 Transmission is exceptionally smooth other than the first few shifts on a cold winter morning .
888 Cruise control gains, RPMs accelerate up hill causing engine to make loud noise while using cruise control, higher in back making it harder to judge while backing up and transmission not completely smooth in take offs .
889 The six speed auto transmission is very smooth .
890 After driving this car for a month it is very obvious to me that there is a design flaw in the transmission .
891 The transmission constantly shifts back and forth between gears .
892 The transmission is just terrible .
893 Transmission is a little different than previous Camrys but MPG and better accel .
894 It has plenty of power for my needs and I have noticed no transmission problems at all .
895 Like everyone else, I have the problem with the transmission .
896 I have had non, stop transmission problems, terrible sunroof noises, very uncharacteristic squeaks and rattles from everywhere in the dash, and unacceptable paint issues .
897 It has been in for a rattling sunroof pan within 1 month of purchase 3 trips for a transmission issue the radio quit working this summer and needed replaced and now the oil line for the VVTi has ruptured .
898 The transmission leaves a lot to be desired .
899 Some have found the transmission shifts too much, but it’s only trying to keep the engine in the 2000, 2500 rpm range around town where there’s some torque available .
900 Toyota made a real goof on the engine and transmission !
901 Transmission shifts up and down at highway speeds, which is annoying .
902 However, the transmission is sloppy .
903 It’s automatic transmission is jerky and sometimes hesitant about changing gears .
904 MPG is not better than 24mpg w the 4CYL, the transmission slips, the throttle by wire has been non, responsive on several occasions, the ergonomics are off , and the dealership is very proud of their product, too proud .
905 Also, the shifting in the transmission is herky jerky .
906 the auto transmission is very poorly designed and Toyota hasn’t decided what to do .
907 When approaching a stop with little or no gas pedal pressure, the transmission downshifts normally until the car shifts gears and suddenly lurches ahead at a higher speed .
908 After purchasing my 2007 Camry, which was a hassle because the salesman was pushy, I started having trouble with the transmission slipping !
909 The transmission hesitates, also downshifts, hunting between gears, then lurches .

910 The engine has a horribly long hesitation when trying to accelerate and the transmission downshifts with the slightest throttle pressure and on the most minor upgrades .
911 The only negative is the shifting of the transmission from 40
912 The transmission is the nightmare many have already talked about .
913 Perhaps the most annoying thing to me, the transmission kicks up and down on shallow declines , never had this in any automatic before .
914 If you care about a smooth transmission run don’t walk away from the 4cyl automatic 2007 camry .
915 This Accord model has a great balance of features that blends attractive styling, driveablity, build quality, economy, and comfort with all the loaded options that I will enjoy over several years and 100000
916 The car is roomy inside, comfortable, handles and performs great and is fun to drive .
917 Cloth front seats big & comfortable .
918 Seats are stiff but once adjusted seem to become more comfortable .
919 Traded in my Oddysey for better gas mileage and more comfort .
920 So far not super impressed with gas mileage, and comfort, well lets just say my dealership just ordered a new seat cushion for me today .
921 Comfort is my only real complaint .
922 My my, I have never experienced such smooth performance, stability, pick, up, mileage and comfort that I am enjoying with my new 2008 Honda Accord .
923 On the inside, it was for the most part comfortable and luxurious .
924 The only hiccup I can report is that I think that the seats in our 2008 Odyssey are a bit more comfortable .
925 Don’t get me wrong, the Accord is a comfortable car, I am just a big guy and the seats just feel like they could use a little more of something .
926 The 2008 Honda Accord EX, L V6 is an ideal combination of comfort , economy, and pleasure !
927 No, the Honda does not have the anti, sway of those vehicles in high, cornering speeds, but it is more comfortable .
928 Was looking for something fun, fast, comfortable and practical and got it all with this car .
929 There is an amazing comfort level with this car .
930 Comfort based on the quality and attention to detail Honda efficiently packs into this newly reclassified full size car .
931 The interior is comfortable, neat and you can find everything within reach .
932 The heated leather seat is very comfortable and audio system is rocking .

933 Although it’s a lower trim level, it has high quality interior trim very comfortable seats and and very smooth, quiet ride .
934 I love the interior layout and comfort .
935 My only complaint is the seat is not comfortable for a long period of driving and if it is raining and you barely roll the window down uou will get soaked .
936 Very roomy and comfortable even with 5 adults .
937 At 6’3 I can sit comfortably in the drivers seat and have an unobstructed view out the windows .
938 I commute alot, so interior is important to me, and its leather is does not seem cheap and comfort is top notch .
939 Gliding can best define the comfort and quietness of the ride inside .
940 With the leather seats, comfort is close to EX, L’s at a best buy price .
941 Traded in a 2007 Hyundai Azera Limited that depreciated too fast for my comfort zone .
942 Leather seats are very comfortable .
943 Interior is very comfortable w ergonomic design in mind .
944 Front seats much more comfortable .
945 Comfortable, good in snow, easy to drive .
946 The driver, side seat is not comfortable .
947 This car is very comfortable car to drive .
948 Driver seat could be more comfortable however, but I love everything about it .
949 I find the interior comfortable for short and long trips .
950 My wife does say the vehicle is not as comfortable for long trips as other cars we’ve owned .
951 Comfortable ride no thanks to the comfort of the drivers seat !
952 Very comfortable drive, holds the road very nicely and a blast to drive .
953 The Accord is so large, comforting, and easy to understand radio system .
954 I was slightly concerned about all the reviews with the seats being uncomfortable .
955 Leather seats were comfortable .
956 Leather interior very comfortable .
957 My conclusion after doing a ton of research regarding safety, reliability, comfort and gas mileage :
958 the Hyundai Sonata is thousands of dollars cheaper and matches the Camry in all respects except comfort .
959 Bottom line was that I was going to be in that driver’s seat for years to come and I was not going to skimp on the critical comfort factor .
960 While the ’03 was roomy and comfortable, the steering and handling were very vague .
961 The interior is upgraded markedly, and although there is a bit

less headroom, the added telescoping feature of the steering wheel combined with the greater travel of the seat yields greater comfort .
962 , a luxurious comfort feature, and a fuel consumption that is best in the class .
963 Nice looking interior but seats are very hard and are not comfortable for long trips .
964 Top notch rating on interior comfort .
965 I purchased a Camry LE approximately 2 months ago, it's a smooth comfortable ride .
966 I selected the Camry for its comfort and reliability .
967 This new Camry is indeed very comfortable with quiet and soft ride .
968 Very uncomfortable when driving long distances .
969 I am not real fond of the electric seat and I find it is not as comfortable as my F150 pickup on trips .
970 This car is easy to drive, great gas mileage and comfortable .
971 However, when we drove the Camry we were impressed with its looks and the comfort of the ride .
972 Once you learn the responsiveness of the gas pedal, you can get either the performance or mileage you want out of a 2 .
973 Gas mileage is 28 mpg on combined and 32 when we were on trip of 100 miles .
974 Comfort is great, mileage is good overall, better on the road than expected , compared to my 1999 Camry .
975 Downshifting on grades is annoying, but overall car is good with decent mileage, and good value for the money .
976 The 2000 Bonneville I traded was not as refined or quiet, but rode better and got nearly the same mileage .
977 Reliable and predicted to get great mileage .
978 My conclusion after doing a ton of research regarding safety, reliability, comfort and gas mileage :
979 My overall mileage has been 23, 24 .
980 Probably the best 4 cylinder motor on the market with excellent mileage and performance .
981 Powerfull, quiet, good gas mileage, excellent workmanship, good audio system .
982 Poor mileage is yet another factor as is the numerous blind spots resulting from the appearance over proper design issues .
983 The engine, ride and gas mileage is great .
984 It gets great gas mileage for a larger car .
985 Once broken in mileage is steady at 29, 32 mpg .
986 The transmission is jerky and the gas mileage is terrible .
987 Was able to get a Polished Metal w Gray interior right off the truck .
988 Center instrument panel hard to read in bright daylight Was looking at new Nissan Coupe also, but purchased Honda because of larger interior .

989 I commute alot, so interior is important to me, and its leather is does not seem cheap and comfort is top notch .
990 Interior is very comfortable w ergonomic design in mind .
991 Purchased Accord Feb 2008 V6 EX Cloth interior .
992 I find the interior comfortable for short and long trips .
993 Tonight I find that my headlights, brake lights, and interior lights all flicker every 20 seconds when the air conditioner is running .
994 Interior is good but has quite a few rattles .
995 I am a bit disappointed with the interior planning .
996 At highway speeds, the interior remains quiet, with little to no wind or road noise .
997 However I have few complaints about the interior .
998 IMHO, the exterior and performance are way better than other trims, though you can't compare interior of SE with XLE .
999 Interior is extremely quiet on the highway .
1000 Love the looks, power, roomy interior, good mileage at 32 hwy and 25 city .
1001 Interior still has too much hard plastic, especially the steering wheel, which has a raised crease hitting on the fingers as a constant reminder .
1002 It has nice luxury interior , but it also has nice pick up speed and is very roomy .
1003 Excellent interior build quality .
1004 The new interior design is ok to me, the blue, backgound center console is a little bit awkward, too bright at night .
1005 Leather interior very comfortable .
1006 Nice looking interior but seats are very hard and are not comfortable for long trips .
1007 I am in, love with my moonroof, 440 watt 6, disc stereo system, and the interior gauges that illuminates in blue is probably my favorite .
1008 My Barcelona red metallic exterior and dark charcoal interior are a perfect combination .
1009 Top notch rating on interior comfort .
1010 All around this car is amazing, its sleek exterior and futuristic interior is sure to turn some heads .
1011 Second, the interior designer should be fired .
1012 It is surprising how spacious the interior is on a long trip .
1013 The plastic interior looks and feels cheap .
1014 The interior is okay and I have not had any rattles or squeaks .
1015 The interior rattles, with pieces falling off, the ride is not that great, and the handling of the vehicle is absolutely the worst I have ever experienced .
1016 Mileage looks like it will be a little less than the older V6 Hondas
1017 Some here have complained of poor gas mileage, but I've had mine almost two weeks, driven 300 miles so far in mostly city

driving, and have a bit more than a quarter of a tank left .
1018 5L V6 scoots sporty handling and acceleration good sporty leather seats highway gas mileage appearance package worth having no dealer service yet Negatives :
1019 Tough negotiations w 6 Wash DC dealers city gas mileage road noise no keyless memory link w driver profiles steering wheel quality and size console storage tray outside mirrors don ?
1020 VCM works out nice for better mileage .
1021 hard seats, hard ride, more road noise than expected, disappointing gas mileage .
1022 And great gas mileage averaging 28 .
1023 Very disappointed in mileage .
1024 I love the appearance of the car from the outside, and it has a much bigger feel to it, ride is a little stiff but smooth, engine is very responsive, however gas mileage is diappointing getting 5 mpg less then 06 Accord .
1025 My only really complaint is the gas mileage is not as good as advertised .
1026 Mileage is decent around 24, 27 .
1027 Traded in my Oddysey for better gas mileage and more comfort .
1028 So far not super impressed with gas mileage, and comfort, well lets just say my dealership just ordered a new seat cushion for me today .
1029 Gas mileage will surely improve, hopefully .
1030 The trade, off is a bit lower mileage but still better than most out there .
1031 Having had to give up my 99 Accord due to very high mileage 170K
1032 My my, I have never experienced such smooth performance, stability, pick, up, mileage and comfort that I am enjoying with my new 2008 Honda Accord .
1033 Mileage so far is the big disappointment, low 20’s, old Accord was never below 27mpg .
1034 Telling me how good the gas mileage is not true .
1035 Gas mileage is great for a vehicle with this type of performance .
1036 The car has ample power, but the gas mileage has been disappointing .
1037 The car is as big and roomy inside as my old Acura Rl, handles better and gets better gas mileage .
1038 It’s fun to drive, and gets great gas mileage .
1039 Handles great, good mileage, and wonderful ride .
1040 The Accord was quiet, was easy to drive, seemed to be the right size, and would provide decent mileage .
1041 It was the combination I was looking for, great look, good value, decent gas mileage, and Honda’s resale value .
1042 The windshield wash barely hits the windshield but I am mostly disappointed in the gas mileage .

1043 I do not know what these people are talking about saying it gets bad gas mileage !
1044 Car rides great, good fuel mileage .
1045 Gas mileage is not as advertised , 25 mpg at most .
1046 Gas mileage is OK, averaging about 23, 24 city , 31 highway normal driving, I don't drive fast, but I don't drive slow either .
1047 Fuel mileage is disappointing 15 18 city 22 26 hwy .
1048 Gas mileage not quite as good as advertised .
1049 Gas mileage is above average .
1050 Great power, great ride, and pretty good fuel mileage .
1051 Gas mileage is at it's highest 24 mpg usually 22 mpg hwy .
1052 Little 4cyl 5 spd LX and it got awesome gas mileage .
1053 My my, I have never experienced such smooth performance, stability, pick, up, mileage and comfort that I am enjoying with my new 2008 Honda Accord .
1054 I admire engine performance and comfort while driving at least 30 mile a day to job .
1055 I have owned 4 honda's and have come to rely on the fantastic quality of performance and lack of maintenance issues .
1056 The car is superb, performance, styling, quality, engineering, fit and finish , the whole banana !
1057 The performance is incredible !
1058 Gas mileage is great for a vehicle with this type of performance .
1059 I could not be happier with the performance and ride of this car .
1060 When I first tested the EX, L V6, the performance and handling of the car sold me, I had to get it and I did .
1061 Honda has outdone itself on styling and performance .
1062 Its ride, comfort and overall performance is an absolute joy .
1063 Excellent interior build quality .
1064 Was sold by the reputation for quality, reliability, and the 2007 redesign .
1065 Vehicle ride is extremely smooth, compliant and quiet , very close to Lexus quality for thousands of dollars less .
1066 The new 2007 Camry should have the higher quality than 1997 Carmry, but not in my case .
1067 I just feel the car is quality throughout .
1068 The 07 Camry is a high quality car at a very affordable price .
1069 However, the quality is absolutely terrible for a Toyota .
1070 I will keep this car, but I hope Toyota improves their quality to their older standards of the mid 90s .
1071 My transmission works seamlessly and there are no quality issues whatsoever .
1072 I was driving 91 Camry for long time and it's quality deeply impressed me .
1073 While I love the design, the poor components, sub, par fit, and,

finish, poor quality control, and unreliable work on the part of dealership techs will make me question the quality of any future Toyota vehicle .
1074 Seats are stiff but once adjusted seem to become more comfortable .
1075 The seats are very firm, but getting used to this .
1076 The seats in my 2008 which is just like a 2009 are considerably less than I'm used to from Honda .
1077 The only hiccup I can report is that I think that the seats in our 2008 Odyssey are a bit more comfortable .
1078 Don't get me wrong, the Accord is a comfortable car, I am just a big guy and the seats just feel like they could use a little more of something .
1079 I have two herniated disks and the seats of the Honda have alleviated the pain in my legs and back when I drive .
1080 Although it's a lower trim level, it has high quality interior trim very comfortable seats and and very smooth, quiet ride .
1081 Decent accel, huge back seat for my kids baby seats large friends .
1082 we don't need moonroof, heated seats side mirrors we live in S .
1083 With the leather seats, comfort is close to EX, L's at a best buy price .
1084 Seats are a bit too firm for me .
1085 Leather seats are very comfortable .
1086 The inside and outside pads should ALWAYS wear evenly Always had stiff ride and seats .
1087 I have a bad lower back, and the lumbar support on the seats is a life saver !
1088 Front seats much more comfortable .
1089 The satellite radio cuts out constantly, the heated seats are barely warm, the sound system is pathetic and the brakes wore out around 15,000 miles google it .
1090 We are both tall, 5'11 and 6'2 and have no problems with the seats .
1091 After driving it for a few months I found the seats are tough on the lower back on long runs and it need a few more inches to go back .
1092 Seats are too firm and leather is quite hard in character and feel .
1093 I was slightly concerned about all the reviews with the seats being uncomfortable .
1094 I love the seats, they are supportive .
1095 LE 2007, 4cy, minor transmission hesitations as I see many other are experencing .
1096 Transmission does not know sometimes what it is doing when it ?
1097 The transmission is flawed, it takes a few seconds for it to speed up, but once it goes it goes fast, I love the shift gate

, great for easy passing !
1098 Due to lack, of, power or transmission problem, car down, shifts revs to 3000
1099 Transmission is smooth and the 2 .
1100 I did have a problem with the transmission but took it in and they reprogrammed the 2 computer chips in there and WOW what a difference that made .
1101 The transmission and cruise control is a joke .
1102 After about 3000 miles on my 2007 Camry XLE V6 6sp Auto, it's been in the shop 4 times already and the last call from the dealer was to replace the transmission .
1103 transmission hunts for gears, ride quality much worse than even a mediocre car, Auto sound level doesn't work, accessory outlets do not work unless car is running or ac is on , radio shuts off when engine is shut off .
1104 The transmission is not the smoothest .
1105 268 HP V6 with 6 speed auto transmission is very responsive and smooth .
1106 The transmission is seamless and, with six forward gears, the engine is virtually never strained in ordinary driving .
1107 8 Transmission hunts for gears 9 Driver side head liner molding buzzes .
1108 11 Transmission unexpectly deaccelates during a slow down .
1109 However I have noticed, like others, that the new transmission is not that smooth, especially when accelerating from a stop .
1110 The 5 speed transmission shifts like one would with a manual .
1111 The transmission, or more specifically, the power transfer is scary .
1112 The reprogramming of the transmission shifting seemed to help for awhile, but it's reverted back .
1113 The transmission computer is a major issue .
1114 Dealers do not handle the transmission matters well as I've had no luck in clearing up the inadequacies .
1115 The transmission is jerky and the gas mileage is terrible .
1116 It has major transmission issues, which I have had fixed twice .
1117 My transmission works seamlessly and there are no quality issues whatsoever .
1118 The transmission is driving me crazy .
1119 While the transmission is downshifting you can feel it thumping through the gears and an audible banging sound can be heard coming from the transmission .
1120 Transmission was very rough, dealership reprogrammed, it's ok now .
1121 The new transmission shifts too frequently to truly optimize gas consumption .
1122 The transmission is the absolute WORST, it is very dangerous and can cause an accident .
1123 They have finally fixed my transmission .

1124 Only problem has been the proprietary transmission glitch everyone talks about .
1125 I have 4 cyl with manual transmission , lack of power but great fuel economy .
1126 Transmission big issue and also rattles more than the 2001 Avalon that had 175K miles .

APPENDIX C. SOURCE CODE IN PYTHON FOR CRF IMPLEMENTATION

```
1  # -*- coding: utf-8 -*-
2  """
3  Created on Wed Aug 29 17:18:19 2018
4
5  @author: Yue Ming
6  """
7
8  """
9  CRF Implementation in Python
10 """
11
12 ####################
13 # Define Functions #
14 ####################
15 #################
16 # Create Corpus #
17 #################
18
19 from collections import defaultdict
20 def read_corps(corpsfile):
21     corps = []
22     words = ['<S>'] # the words list start with "<S>", as initial
           state and end state
23     tags  = [  0  ]
24     tagids = defaultdict(lambda: len(tagids)) # create a
          collection for tags
```

```
25      tagids['<S>'] = 0
26      for texts in corpsfile:
27          for word in texts:
28              words.append(word[0].lower()) # if not a number,
                    transform to lower case
29              tags.append(tagids[word[1]])
30          words.append('<S>') # end a words list for the current
                sentence with "<S>" as end state
31          tags.append(0)
32          corps.append((words, tags))
33          # reset lists for new sentence
34          words = ['<S>']
35          tags  = [  0  ]
36      return corps, tagids
37
38
39  #################
40  # log functions #
41  #################
42
43  class Logspace:
44      def __init__(self):
45          self.LOGZERO = np.nan
46
47      def eexp(self, x): # take exp value
48          if np.isnan(x):
49              return 0
50          else:
51              return np.exp(x)
```

```
52
53      def eln(self, x): # take natural log
54          if x == 0:
55              return self.LOGZERO # if 0, return nan
56          elif x>0:
57              return np.log(x)
58          else:
59              print ('Error! Negative input.')
60              return np.nan
61
62      def elnsum(self, elnx, elny):
63          if np.isnan(elnx):
64              return elny
65          elif np.isnan(elny):
66              return elnx
67          elif elnx > elny:
68              return elnx + self.eln(1+np.exp(elny-elnx)) # log(x)
                    + log(1 + exp(log(y)-log(x))) = log(x+y)
69          else:
70              return elny + self.eln(1+np.exp(elnx-elny)) # log(y)
                    + log(1 + exp(log(x)-log(y))) = log(x+y)
71
72      def elnproduct(self, elnx, elny): # input log value
73          if np.isnan(elnx) or np.isnan(elny):
74              return self.LOGZERO
75          else:
76              return elnx + elny # log(x*y) = log(x) + log(y)
77
78      def elnmatprod(self, elnx, elny): # log matrix multiplication
```

```
79          xsize = np.size(np.shape(elnx))
80          ysize = np.size(np.shape(elny))
81
82          if xsize == 1 and ysize == 1:
83              r = self.LOGZERO
84              for i in range(np.shape(elnx)[0]):
85                  r = self.elnsum(r, self.elnproduct(elnx[i], elny[
                        i]))
86              return r
87          elif xsize == 1 and not ysize == 1:
88              n = np.shape(elny)[1]
89              r = np.zeros(n)
90              for i in range(n):
91                  r[i] = self.elnmatprod(elnx, elny[:, i]) # x
                        times i th col of y
92              return r
93          elif not xsize == 1 and ysize == 1:
94              n = np.shape(elnx)[0]
95              r = np.zeros(n)
96              for i in range(n):
97                  r[i] = self.elnmatprod(elnx[i, :], elny) # ith
                        row of x times y
98              return r
99          else:
100             m,n = np.shape(elnx)
101             p = np.shape(elny)[1]
102             r = np.zeros((m, p))
103             for i in range(m):
104                 for j in range(p):
```

```
105                     r[i][j] = self.elnmatprod(elnx[i, :], elny[:,
                            j]) # ith row of x times jth col of y
106             return r
107
108     def eexpmat(self,elny): # take matrix exp, input log value
109         expy = np.copy(elny)
110         if np.size(np.shape(elny)) == 1:
111             for i in range(np.shape(elny)[0]):
112                 expy[i] = self.eexp(expy[i])
113         else:
114             for i in range(np.shape(elny)[0]):
115                 for j in range(np.shape(elny)[1]):
116                     expy[i][j] = self.eexp(expy[i][j])
117         return expy
118
119     def elnmat(self,x): # take matrix log, input original value
120         elnx = np.copy(x)
121         if np.size(np.shape(x)) == 1:
122             for i in range(np.shape(x)[0]):
123                 elnx[i] = self.eln(x[i])
124         else:
125             for i in range(np.shape(x)[0]):
126                 for j in range(np.shape(x)[1]):
127                     elnx[i, j] = self.eln(x[i,j])
128         return elnx
129
130 logspace = Logspace()
131
132
```

```
133 ####################################################
134 # Get transition and emission features from corpus #
135 ####################################################
136
137 def getfeatureTS(corps):
138     featuresets = set() # set of features
139     featureT = []
140     featureS = []
141     for corp in corps:
142         for i in range(np.shape(corp[0])[0]):
143             if corp[0][i] == '<S>':
144                 continue
145             if ('S',corp[0][i], corp[1][i]) not in featuresets:
146                 featuresets.add(('S', corp[0][i], corp[1][i]))
147                 featureS.append(('S', corp[0][i], corp[1][i]))
148             if corp[0][i-1] != '<S>':
149                 if ('T', corp[1][i-1], corp[1][i]) not in
                        featuresets: # combine duplicated transition
                        combination to calculate prior probability
150                      featuresets.add(('T', corp[1][i-1], corp[1][i
                            ]))
151                      featureT.append(('T', corp[1][i-1], corp[1][i
                            ]))
152     featureTS = featureT + featureS
153     word_to_tagid = word_tagid_from_featureS(featureS)
154     return featureTS, word_to_tagid, featureT, featureS
155
156
157 ############################################################
```

```
158 # Calculate prior expectation for transition and emission #
159 ############################################################
160
161 def getpriorfeatureE(corps, featureTS):
162     N = np.shape(corps)[0] # size of training set
163     K = np.shape(featureTS)[0] # number of features
164     priorfeatureE = np.zeros(K) # return a new array of given
           shape and type, filled with zeros
165     for corp in corps: # corp is tuple in corps, for each
           sentence tuple in corps
166         for i in range(np.shape(corp[0])[0]):
167             if corp[0][i] == '<S>':
168                 continue
169             try:
170                 idex = featureTS.index(('S', corp[0][i], corp[1][
                       i])) # get index of a word with its tagid
171                 priorfeatureE[idex] += 1.0
172             except:
173                 pass
174             try:
175                 idex = featureTS.index(('T', corp[1][i-1], corp
                       [1][i])) # get index of transition combination
176                 priorfeatureE[idex] += 1.0 # calculate the number
                        of occurrence of a transition combination
177             except:
178                 pass
179     priorfeatureE /=N # divided by the number of sentences
180     return priorfeatureE
181
```

```
182
183 ##############################
184 # Create word-tagid pair list #
185 ##############################
186
187 def word_tagid_from_featureS(featureS): # list of words with
       corresponding features that appeared in training data
188     word_to_tagid = {}
189     for feature in featureS:
190         word = feature[1]
191         state = feature[2]
192         if word in word_to_tagid:
193             word_to_tagid[word].append(state)
194         else:
195             word_to_tagid[word] = [state]
196     return word_to_tagid
197
198
199 ########################
200 # Train feature weights #
201 ########################
202
203 def getpostfeatureE(weights, corps, featureTS, word_to_tagid): #
       see wallach04conditional for details: CRF Probability as
       Matrix Computations
204     K = np.shape(featureTS)[0] # number of features
205     postfeatureE = np.zeros(K) # initialize posterior probability
            of features
206     N = np.shape(corps)[0] # sample size or number of sentences
```

```
207     for corpidx in range(N):
208         corp = corps[corpidx][0][1:-1] # each original sentence
               without <S>
209         lencorp = np.size(corp) # number of words in the sentence
210         Mlist = {}
211         Mlist['mat'] = ['']*(lencorp+1)
212         Mlist['dim'] = [word_to_tagid[corp[i]] for i in range(
               lencorp)]
213         Mlist['len'] = [np.size(word_to_tagid[corp[i]]) for i in
               range(lencorp)]
214         for i in range(lencorp+1):
215             if i == 0: # first word in the sentence doesn't have
                   transition, so only calculate the word's emission
                   weight
216                 d = Mlist['len'][0]
217                 Mlist['mat'][i] = np.zeros((1, d))
218                 for j in range(d):
219                     Mlist['mat'][i][0, j] = weights[featureTS.
                           index(('S', corp[0], word_to_tagid[corp
                           [0]][j]))]
220                 continue
221             if i == lencorp: # last entry is a seudo value,
                   assign a matrix with a col array popped with 0
222                 Mlist['mat'][i] = np.zeros((Mlist['len'][-1], 1))
223                 continue
224             Mlist['mat'][i] = np.zeros((Mlist['len'][i-1], Mlist
                   ['len'][i])) # previous word, current word
225             for d1 in range(Mlist['len'][i-1]):
226                 for d2 in range(Mlist['len'][i]):
```

```
227                     id1 = word_to_tagid[corp[i-1]][d1] # tag of
                           the previous word
228                     id2 = word_to_tagid[corp[i]][d2] # tag of the
                            current word
229                     try:
230                         Sweight = weights[featureTS.index(('S',
                               corp[i], id2))]
231                     except:
232                         Sweight = 0
233                     try:
234                         Tweight = weights[featureTS.index(('T',
                               id1, id2))]
235                     except:
236                         Tweight = 0
237                     Mlist['mat'][i][d1, d2] = Sweight + Tweight
238         z = np.array([[0]]) # Partition function, summation of
               all possible combinations
239         for i in range(lencorp+1): # for each word
240             z = logspace.elnmatprod(z, Mlist['mat'][i])
241         Alphalist = ['']*(lencorp+2)
242         Betalist = ['']*(lencorp+2)
243         Alphalist[0] = np.zeros((1, 1)) # forward array, (row,
               col), initial seudo value, 1*1 matrix of 0
244         Betalist[-1] = np.zeros((Mlist['len'][-1], 1)) # backward
                array (row, col), initial value of last seudo value
               of 0
245         for i in range(1, lencorp+2): # forward array, single row
                matrix
246             Alphalist[i] = logspace.elnmatprod(Alphalist[i-1],
```

```
                Mlist['mat'][i-1])
247         for i in range(lencorp, -1, -1): # backward array, single
                column matrix;
248             Betalist[i] = logspace.elnmatprod(Mlist['mat'][i],
                    Betalist[i+1])
249         for i in range(1, lencorp+1): # for each word
250             d1, d2 = np.shape(Mlist['mat'][i-1]) # row - tags of
                    previous word, col - tags of current word
251             for di in range(d1):
252                 for dj in range(d2):
253                     plocal = logspace.eexp(logspace.elnproduct(
                            logspace.elnproduct(logspace.elnproduct(
                            Alphalist[i-1][0,di], Mlist['mat'][i-1][di
                            ,dj]), Betalist[i][dj,0]), -z[0,0])) # P(
                            Yi-1 = y', Yi = y|x(k),lamda)); the
                            function is computationally convenient
                            using log property
254                     if i == 1: # when i = 1, first word, no
                            transition, only emission; when i =
                            lencorp+1 last element <S>, no
                            transition nor emission
255                         try:
256                             Sidex = featureTS.index(('S', corp[i
                                    -1], Mlist['dim'][i-1][dj]))
257                             postfeatureE[Sidex] += plocal
258                         except:
259                             pass
260                     else:
261                         try:
```

```
262                             Sidex = featureTS.index(('S', corp[i
                                    -1], Mlist['dim'][i-1][dj])) #
                                    emission
263                             postfeatureE[Sidex] += plocal
264                         except:
265                             pass
266                         try:
267                             Tidex = featureTS.index(('T', Mlist['
                                    dim'][i-2][di], Mlist['dim'][i-1][
                                    dj])) # transition
268                             postfeatureE[Tidex] += plocal
269                         except: # if no transition, ignore
270                             pass
271     postfeatureE /= N
272     return postfeatureE
273
274
275 ####################################
276 # Calculate negative-loglikelihood #
277 ####################################
278
279 def getliknegvalue(weights, corps, featureTS, word_to_tagid): #
       minimize negative loglikelihood function
280     K = np.shape(featureTS)[0] # number of features
281     N = np.shape(corps)[0] # number of sentences
282     liknegvalue = 0
283     for corpidx in range(N):
284         corp = corps[corpidx][0][1:-1] # words without <S>
285         tag = corps[corpidx][1][1:-1] # tags without tags for <S>
```

```
286         lencorp = np.size(corp) # number of words in current
               sentence
287         Mlist = {}
288         Mlist['mat'] = ['']*(lencorp+1)
289         Mlist['dim'] = [word_to_tagid[corp[i]] for i in range(
               lencorp)]
290         Mlist['len'] = [np.size(word_to_tagid[corp[i]]) for i in
               range(lencorp)]
291         for i in range(lencorp+1):
292             if i == 0: # if start, only emission
293                 d = Mlist['len'][0]
294                 Mlist['mat'][i] = np.zeros((1, d))
295                 for j in range(d):
296                     Mlist['mat'][i][0, j] = weights[featureTS.
                           index(('S', corp[0], word_to_tagid[corp
                           [0]][j]))]
297                 continue
298             if i == lencorp:
                   # if last, array of 0s
299                 Mlist['mat'][i] = np.zeros((Mlist['len'][-1], 1))
300                 continue
301             Mlist['mat'][i] = np.zeros((Mlist['len'][i-1],Mlist['
                   len'][i]))
302             for d1 in range(Mlist['len'][i-1]):
303                 for d2 in range(Mlist['len'][i]):
304                     id1 = word_to_tagid[corp[i-1]][d1]
305                     id2 = word_to_tagid[corp[i]][d2]
306                     try:
307                         Sweight = weights[featureTS.index(('S',
```

```
                                corp[i], id2))]
308                     except:
309                         Sweight = 0
310                     try:
311                         Tweight = weights[featureTS.index(('T',
                                id1, id2))]
312                     except:
313                         Tweight = 0
314                     Mlist['mat'][i][d1, d2] = Sweight + Tweight
315
316         numerator = 0 # sum of all observed features
317         denominator = np.array([[0]]) # the Z value
318         for i in range(lencorp+1): # for each word
319             denominator = logspace.elnmatprod(denominator, Mlist
                    ['mat'][i])
320             if i == 0: # beginning word
321                 numerator = logspace.elnproduct(numerator, Mlist
                        ['mat'][i][0, Mlist['dim'][i].index(tag[i])])
322             elif i < lencorp: # elsewhere in the sentence, sum
                    all weights of observed features
323                 numerator = logspace.elnproduct(numerator, Mlist
                        ['mat'][i][Mlist['dim'][i-1].index(tag[i-1]),
                        Mlist['dim'][i].index(tag[i])])
324         liknegvalue += (denominator - numerator)/N # negative
                loglikelihood function
325     return liknegvalue[0,0] # a single value
326
327 # Calculate gradient
328 def getgradients(priorfeatureE, weights, corps, featureTS,
```

```
    word_to_tagid):
329     postfeatureE = getpostfeatureE(weights, corps, featureTS,
            word_to_tagid)
330     return postfeatureE - priorfeatureE
331
332
333 ######################
334 # Two-loop recursion  #
335 ######################
336
337 def twoloop(s, y, rho, gk): # compute search direction in L-BFGS,
        approximate inverse of hessian matrix
338     n = len(s)
339
340     if np.shape(s)[0] >= 1:
341         h0 = 1.0*np.dot(s[-1],y[-1])/np.dot(y[-1],y[-1]) # https
                ://en.wikipedia.org/wiki/Limited-memory_BFGS
342     else:
343         h0 = 1
344
345     a = np.empty((n,))
346
347     q = gk.copy() # q is the gradients
348     for i in range(n - 1, -1, -1): # from n-1 to 0 decreasing by
            1
349         a[i] = rho[i] * np.dot(s[i], q) # rho is defined as 1/(
                transpose(yk)*sk)
350         q -= a[i] * y[i]
351     z = h0*q
```

```
352
353     for i in range(n):
354         b = rho[i] * np.dot(y[i], z)
355         z += s[i] * (a[i] - b)
356     return z   # The value of zk is the approximation for the
           direction of steepest ascent
357
358
359 ########################
360 # L-BFGS Optimization #
361 ########################
362
363 def lbfgs(fun, #= getliknegvalue, neg-likelihood function
364           gfun, #= getgradients, first-derivative
365           x0, #= weights, initial weights
366           corps, #= corps,
367           featureTS, #= featureTS,
368           word_to_tagid, #= word_to_tagid,
369           priorfeatureE, #= priorfeatureE,
370           m, # number of previous steps to be stored
371           maxk):
372
373     rou = 0.55 # initial step-size
374     sigma = 0.4
375     epsilon = 1e-5
376     k = 0
377     n = np.shape(x0)[0] # dimension of weights
378     s, y, rho = [], [], []
379     while k < maxk : # max number of iterations
```

```
380         gk = gfun(priorfeatureE, x0, corps, featureTS,
               word_to_tagid) # getgradients(priorfeatureE, weights,
               corps, featureTS, word_to_tagid)
381         if np.linalg.norm(gk) < epsilon:   #  Euclidean norm of
               gk
382             break
383         dk = -1.0*twoloop(s, y, rho, gk) # search directions,
               originally defined as -Hk*gk, but approximated by zk
               from twoloop recursion
384         m0=0;
385         mk=0
386         funcvalue = fun(x0, corps, featureTS, word_to_tagid) #
               getliknegvalue(weights, corps, featureTS,
               word_to_tagid)
387         while m0 < 20: # Armijo Rule to control step size
388             if fun(x0+rou**m0*dk, corps, featureTS, word_to_tagid
                   ) < funcvalue+sigma*rou**m0*np.dot(gk, dk):
389                 mk = m0
390                 break
391             m0 += 1
392         x = x0 + rou**mk*dk # http://www-personal.umich.edu/~
               mepelman/teaching/NLP/Handouts/NLPnotes12_5.pdf
393         sk = x - x0
394         yk = gfun(priorfeatureE, x, corps, featureTS,
               word_to_tagid) - gk
395
396         if np.dot(sk,yk) > 0: # add new value in array
397             rho.append(1.0/np.dot(sk, yk))
398             s.append(sk)
```

```
399             y.append(yk)
400         if np.shape(rho)[0] > m: # delete old value in array
401             rho.pop(0)
402             s.pop(0)
403             y.pop(0)
404 
405         k += 1
406         x0 = x
407         print('Iteration %d, liknegvalue %f'%(k,funcvalue))
408     return x0, fun(x0, corps, featureTS, word_to_tagid)
409 
410 
411 ###################################
412 # Viterbi backtracking algorithm #
413 ###################################
414 
415 def viterbi_backtracking(corps):
416     K = np.shape(featureTS)[0]
417     N = np.shape(corps)[0]
418     path_collection =[]
419     for corpidx in range(N):
420         corp = corps[corpidx][0][1:-1]
421         lencorp = np.size(corp)
422         Mlist2 = {}
423         Mlist2['mat'] = ['']*(lencorp)
424         Mlist2['dim'] = [word_to_tagid[corp[i]] for i in range(
                lencorp)]
425         Mlist2['len'] = [np.size(word_to_tagid[corp[i]]) for i in
                range(lencorp)]
```

```
426         for i in range(lencorp):
427             if i == 0:
428                 d = Mlist2['len'][0]
429                 Mlist2['mat'][i] = np.zeros((1, d))
430                 for j in range(d):
431                     Mlist2['mat'][i][0, j] = post_weights[
                            featureTS.index(('S', corp[0],
                            word_to_tagid[corp[0]][j]))]
432                 continue
433             Mlist2['mat'][i] = np.zeros((Mlist2['len'][i-1],
                   Mlist2['len'][i])) # previous word, current word
434             for d1 in range(Mlist2['len'][i-1]):
435                 for d2 in range(Mlist2['len'][i]):
436                     id1 = word_to_tagid[corp[i-1]][d1] # tag of
                            the previous word
437                     id2 = word_to_tagid[corp[i]][d2] # tag of the
                             current word
438                     try:
439                         Sweight = post_weights[featureTS.index(('
                                S', corp[i], id2))]
440                     except:
441                         Sweight = 0
442                     try:
443                         Tweight = post_weights[featureTS.index(('
                                T', id1, id2))]
444                     except:
445                         Tweight = 0
446                     Mlist2['mat'][i][d1, d2] = Sweight + Tweight
447         path = [] # store path
```

```
448         for i in range(lencorp):
449             if i == 0: # beginning word
450                 score_prev = Mlist2['mat'][i] # i-1
451                 continue
452             score_current = np.zeros((Mlist2['len'][i-1], Mlist2
                    ['len'][i]))
453             # score_M will always be a row matrix, it is the
                    column argmax
454             for d1 in range(np.size(score_prev)):
455                 for d2 in range(Mlist2['len'][i]):
456                     score_current[d1,d2] = score_prev[0,d1] +
                            Mlist2['mat'][i][d1, d2]
457             score_prev = np.amax(score_current, axis=0).reshape
                    (1, Mlist2['len'][i]) # update score_pre for next
                    word
458             max_index = score_current.argmax(axis=0)
459             from_ = []
460             to_ = []
461             for loc_max in range(np.size(max_index)):
462                 from_.append(Mlist2['dim'][i-1][max_index[loc_max
                        ]])
463                 to_.append(Mlist2['dim'][i][loc_max])
464             path.append(list(zip(from_, to_)))
465
466         # backtracking
467         max_to_ = score_prev.argmax(axis=1)[0] # determine the
                column of max score
468         final_path = [] # store backtracking path
469         for pth in range(len(path), -1, -1):
```

```
470             if pth == len(path):
471                 node_to = path[pth-1][max_to_][1] # ending node
472                 node_from = path[pth-1][max_to_][0]
473                 final_path.append(node_to)
474                 final_path.append(node_from)
475                 continue
476             if pth == 0:
477                 break
478             node_from = [num for num in path[pth-1] if (node_from
                    in num) == True][0][0] # update node_from
479             final_path.append(node_from)
480         final_path.reverse()
481         path_collection.append(final_path)
482
483     return path_collection
484
485
486 ##########################
487 # Print Confusion Matrix #
488 ##########################
489
490 def print_cm(cm, labels, hide_zeroes=False, hide_diagonal=False,
       hide_threshold=None):
491     """pretty print for confusion matrixes"""
492     columnwidth = max([len(x) for x in labels] + [5])  # 5 is
           value length
493     empty_cell = " " * columnwidth
494     # Print header
495     print("    " + empty_cell, end=" ")
```

```
496     for label in labels:
497         print("%{0}s".format(columnwidth) % label, end=" ")
498     print()
499     # Print rows
500     for i, label1 in enumerate(labels):
501         print("    %{0}s".format(columnwidth) % label1, end=" ")
502         for j in range(len(labels)):
503             cell = "%{0}.1f".format(columnwidth) % cm[i, j]
504             if hide_zeroes:
505                 cell = cell if float(cm[i, j]) != 0 else
                        empty_cell
506             if hide_diagonal:
507                 cell = cell if i != j else empty_cell
508             if hide_threshold:
509                 cell = cell if cm[i, j] > hide_threshold else
                        empty_cell
510             print(cell, end=" ")
511         print()
512
513
514 ############################
515 # Plot of confusion matrix #
516 ############################
517
518 def plot_confusion_matrix(cm,
519                           target_names,
520                           title='Confusion matrix',
521                           cmap=None,
522                           normalize=True):
```

```
523     """
524     given a sklearn confusion matrix (cm), make a nice plot
525
526     Citiation
527     ---------
528     http://scikit-learn.org/stable/auto_examples/model_selection/
           plot_confusion_matrix.html
529
530     """
531     import matplotlib.pyplot as plt
532     import numpy as np
533     import itertools
534
535     accuracy = np.trace(cm) / float(np.sum(cm))
536     misclass = 1 - accuracy
537
538     if cmap is None:
539         cmap = plt.get_cmap('Blues')
540     plt.figure(figsize=(12, 10), dpi=300)
541     plt.imshow(cm, interpolation='nearest', cmap=cmap)
542     plt.title(title)
543     plt.colorbar()
544
545     if target_names is not None:
546         tick_marks = np.arange(len(target_names))
547         plt.xticks(tick_marks, target_names, rotation=45)
548         plt.yticks(tick_marks, target_names)
549     if normalize:
550         cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
```

```
551     thresh = cm.max() / 1.5 if normalize else cm.max() / 2
552     for i, j in itertools.product(range(cm.shape[0]), range(cm.
           shape[1])):
553         if normalize:
554             plt.text(j, i, "{:0.4f}".format(cm[i, j]),
555                      horizontalalignment="center",
556                      color="white" if cm[i, j] > thresh else "
                            black")
557         else:
558             plt.text(j, i, "{:,}".format(cm[i, j]),
559                      horizontalalignment="center",
560                      color="white" if cm[i, j] > thresh else "
                            black")
561     plt.tight_layout()
562     plt.ylabel('True label')
563     plt.xlabel('Predicted label\naccuracy={:0.4f}; misclass={:0.4
           f}'.format(accuracy, misclass))
564     plt.show()
565
566
567 ######################
568 # Extract word index #
569 ######################
570
571 def word_index_extractor(word_type, word_path_list):
572     word_index =[]
573     for i in word_path_list:
574         word_loc = []
575         for word in word_type:
```

```
576             if word not in i:
577                 continue
578             word_loc += ([idx for idx, w in enumerate(i) if w ==
                    word]) # extract the index of satisfied word POS
579         word_index.append(sorted(word_loc)) # maintain word's
                order
580     return word_index
581
582
583 ##############################
584 # Extract corresponding word #
585 ##############################
586
587 from operator import itemgetter
588 def word_extractor(word_index, tokenized_sentence_list):
589     type_word = []
590     for i in range(len(tokenized_sentence_list)):
591         if len(word_index[i]) == 0: # if the word of this type
                doesn't appear in the sentence, it's an empty element
                with length 0
592             actual_word = []
593             type_word.append(actual_word) # append empty element
                    to the list in order to maintain position
594             continue
595         actual_word = itemgetter(*word_index[i])(
                tokenized_sentence_list[i])
596         type_word.append(actual_word)
597     return type_word
598
```

```
599
600 ##################################
601 # Output corresponding sentence #
602 ##################################
603
604 def expect_sentence(expect_index, wanted_word_list):
605     expect_sent = []
606     for i in range(len(expect_index)):
607         if len(expect_index[i]) == 0:
608             continue
609         expect_sent.append(wanted_word_list[i])
610     return expect_sent
611
612 ##################################
613 # ---- End of function list ---- #
614 ##################################
615
616
617 ###############
618 # Import data #
619 ###############
620
621 import numpy as np
622 import pickle, pprint
623
624 # load train_sentence_tagged
625 pkl_file1 = open('train_sentence_tagged.pkl', 'rb')
626 train_sentence_tagged = pickle.load(pkl_file1)
627 pkl_file1.close()
```

```
628
629 # load test_sentence_tagged
630 pkl_file2 = open('test_sentence_tagged.pkl', 'rb')
631 test_sentence_tagged = pickle.load(pkl_file2)
632 pkl_file2.close()
633
634
635 ################
636 # CRF Training #
637 ################
638
639 corps, tagids = read_corps(train_sentence_tagged)
640
641 featureTS, word_to_tagid, featureT, featureS = getfeatureTS(corps
       ) # obtain collection of features
642
643 K = np.shape(featureTS)[0] # Total number of features
644 N = np.shape(corps)[0] # Total number of sentences
645 priorfeatureE = getpriorfeatureE(corps, featureTS) # calculate
       prior expectation
646 weights = np.array([1.0/K]*K) # initial weight on each feature
647
648 weights, likelyfuncvalue = lbfgs(fun = getliknegvalue, gfun =
       getgradients, x0 = weights, corps = corps, featureTS =
       featureTS, word_to_tagid = word_to_tagid, priorfeatureE =
       priorfeatureE, m=10, maxk = 100)
649
650 np.savetxt('crfweightsCar.out', weights, delimiter=',')
651
```

```
652 # Trained weights
653 post_weights = np.genfromtxt('crfweightsCar.out', delimiter=',')
654
655
656 ######################################
657 # Plot Convergence of Negloglikihood #
658 ######################################
659
660 import matplotlib.pyplot as plt
661 plt.rcParams['axes.labelsize'] = 10
662 plt.rcParams['xtick.labelsize'] = 10
663 plt.rcParams['ytick.labelsize'] = 10
664
665 import codecs
666 # import neglikelihood value
667 likelihoodlist = []
668 with codecs.open('CarNeglikelihood.txt','r') as f:
669     for line in f:
670         likelihoodlist.append(float(line.split(u'\uff1a')[-1].
              split()[0]))
671 plt.plot(likelihoodlist[:200],'-k')
672 plt.plot(likelihoodlist[:200],'+r')
673 plt.title('Convergence of Negative Log-Likelihood using L-BFGS:
       100 Iterations')
674 plt.xlabel('Iteration')
675 plt.ylabel('Negative Log-Likelihood')
676
677
678 from scipy.stats.kde import gaussian_kde
```

```
679 # Create the kernel, given an array and it will estimate the
       probability over that values
680 kde = gaussian_kde(post_weights)
681 # Calculated the values over which the kernel will be evaluated
682 dist_space = np.linspace( min(post_weights)-0.01*(max(
       post_weights)-min(post_weights)), max(post_weights), 400 )
683
684 fig,axes = plt.subplots(nrows=2, ncols=1, figsize=(12,10))
685 plt.subplots_adjust(wspace = None, hspace=0.3)
686
687 axes[0].plot(post_weights)
688 axes[0].set_title('Plot of Predicted Feature Weights - 100
       iterations')
689 axes[0].set_xlabel('Features')
690 axes[0].set_ylabel('Weights')
691
692 axes[1].plot(dist_space, kde(dist_space),'k', marker = u'$\circ$
       ')
693 axes[1].set_title('Plot of Predicted Weights Probability Density
       - 100 iterations')
694 axes[1].set_xlabel('Weights')
695 axes[1].set_ylabel('Probability Density')
696
697
698 ##############
699 # Validation #
700 ##############
701
702 import random
```

```
703 from sklearn.metrics import precision_score, recall_score
704 from sklearn.metrics import f1_score
705 from sklearn.metrics import accuracy_score
706 
707 validate_train = train_sentence_tagged.copy()
708 vali_precision_score = []
709 vali_recall_score = []
710 vali_f1_score = []
711 
712 for vali in range(200):
713     random.shuffle(validate_train)
714     validate_set = validate_train[:100]
715     corps_vali, tagids_vali = read_corps(validate_set)
716     path_collection = viterbi_backtracking(corps_vali)
717 
718     # True Path with Tag
719     path_true_tag_collection = []
720     for k in validate_set:
721         path_true = []
722         for l in k:
723             path_true.append(l[1])
724         path_true_tag_collection.append(path_true)
725 
726     # Predicted Path with Tag
727     path_predict_tag_collection = []
728     for k in path_collection:
729         tag_predict = []
730         for l in k:
731             tag_predict.append(list(tagids.keys())[list(tagids.
```

```
                values()).index(l)])
732          path_predict_tag_collection.append(tag_predict)
733
734      path_true_list = [item for sublist in
            path_true_tag_collection for item in sublist]
735      path_predict_list = [item for sublist in
            path_predict_tag_collection for item in sublist]
736
737      # Create collection of evaluation metric scores for
            validation
738      vali_precision_score.append(precision_score(path_true_list,
            path_predict_list, average='macro'))
739      vali_recall_score.append(recall_score(path_true_list,
            path_predict_list, average='macro'))
740      vali_f1_score.append(f1_score(path_true_list,
            path_predict_list, average='macro'))
741
742  # Combine 3 metrics into 1 dataframe
743  import pandas as pd
744  vali_performance = pd.DataFrame(np.column_stack([
        vali_precision_score, vali_recall_score, vali_f1_score]),
        columns=['Precision', 'Recall', 'F1_score'])
745
746  vali_performance.to_csv("vali_performance.csv", index=False)
747  vali_performance.mean() # Precision
748                          # Recall
749                          # F1_score
750  vali_performance.std()  # Precision
751                          # Recall
```

```
752                         # F1_score
753
754 # Histogram of measures
755 import matplotlib.pyplot as plt
756 vali_hist = vali_performance.hist(bins=40, grid=False, figsize
       =(8,10), layout=(3,1), sharex=True, color='#416eaf', zorder=2,
        rwidth=0.9)
757
758 for i,x in enumerate(vali_hist):
759     # Switch off ticks
760     x.tick_params(axis="both", which="both", bottom="off", top="
          off", labelbottom="on", left="off", right="off", labelleft
          ="on")
761
762     # Draw horizontal axis lines
763     vals = x.get_yticks()
764     for tick in vals:
765         x.axhline(y=tick, linestyle='dashed', alpha=0.4, color='#
              eeeeee', zorder=1)
766
767     # Set x-axis label
768     x.set_xlabel("Measurement Level", labelpad=20, weight='bold',
          size=12)
769
770     # Set y-axis label
771     if i == 1:
772         x.set_ylabel("Counts", labelpad=50, weight='bold', size
              =100)
773
```

```
774     # Format y-axis label
775     x.yaxis.set_major_formatter(plt.ticker.StrMethodFormatter('{x
            :,g}'))
776
777     x.tick_params(axis='x', rotation=0)
778
779
780 ##############
781 # Prediction #
782 ##############
783
784 # post_weights
785 # corps_test
786 corps_test, tagids_test = read_corps(test_sentence_tagged)
787 path_collection = viterbi_backtracking(corps_test)
788
789
790 ######################
791 # Calculate Mismatch #
792 ######################
793
794 # since tagids_test is different from tagids from training,
795 # so replace tagid with true tags
796
797 # True Path with Tag
798 path_true_tag_collection = []
799 for k in test_sentence_tagged:
800     path_true = []
801     for l in k:
```

```
802         path_true.append(l[1])
803     path_true_tag_collection.append(path_true)
804
805 # Predicted Path with Tag
806 path_predict_tag_collection = []
807 for k in path_collection:
808     tag_predict = []
809     for l in k:
810         tag_predict.append(list(tagids.keys())[list(tagids.values
                ()).index(l)])
811     path_predict_tag_collection.append(tag_predict)
812
813 # Confusion Matrix
814 from sklearn.metrics import confusion_matrix
815 # convert to list structure
816 path_true_list = [item for sublist in path_true_tag_collection
       for item in sublist]
817 path_predict_list = [item for sublist in
       path_predict_tag_collection for item in sublist]
818
819 labels = list(set(path_true_list+path_predict_list))
820
821 conf_mx = confusion_matrix(path_true_list, path_predict_list,
       labels)
822
823 # Print confusion matrix
824 print_cm(conf_mx, labels)
825 # output to Confusion_matrix.xlsx
826
```

```
827 # read in confusion matrix data as dataframe
828 conf_m_df = pd.read_excel('Confusion_matrix.xlsx')
829
830 # Plot confusion matrix
831 plot_confusion_matrix(cm = conf_m_df.values, normalize = False,
       target_names = labels, title = "Confusion Matrix")
832
833
834 ##################
835 # Plot of Errors #
836 ##################
837
838 error_mx = conf_mx.copy()
839 np.fill_diagonal(error_mx, 0) # fill diagonal with 0s to keep
       errors only
840 print_cm(error_mx, labels)
841 # save as Error_matrix.xlsx
842 Err_m_df = pd.read_excel('Error_matrix.xlsx')
843 plot_confusion_matrix(cm = Err_m_df.values, normalize = False,
       target_names = labels, title = "Error Matrix")
844
845 # Normalized Errors
846 row_sums = conf_mx.sum(axis=1, keepdims=True) # col: axis=0
847 norm_conf_mx = conf_mx/row_sums
848 # fill diagonal with 0s to keep errors only
849 print_cm(norm_conf_mx, labels)
850 # save as Norm_Error_matrix.xlsx
851
852 Err_m_df = pd.read_excel('Norm_Error_matrix.xlsx')
```

```
853 plot_confusion_matrix(cm = Err_m_df.values, normalize = False,
       target_names = labels, title = "Normalized Error Matrix")
854
855
856 ##############################################
857 # Calculate Precision, Recall, F1, Accuracy #
858 ##############################################
859
860 test_precision_score_score = precision_score(path_true_list,
       path_predict_list, average='macro')
861 test_precision_score_score = precision_score(path_true_list,
       path_predict_list, average='micro')
862 test_precision_score_score = precision_score(path_true_list,
       path_predict_list, labels = ['RBR','RBS','WRB','CC','VBD','EX
       ','VBN','NNS','NNP','.','TO','VBG','VBP','JJ','JJS','CD','VB
       ','PRP','MD','NN','JJR','DT','IN','WDT','WP','RP','VBZ','RB','
       POS','#','PRP$'], average=None) # for each label
863
864 test_recall_score = recall_score(path_true_list,
       path_predict_list, average='macro')
865 test_recall_score = recall_score(path_true_list,
       path_predict_list, average='micro')
866 test_recall_score = recall_score(path_true_list,
       path_predict_list, labels = ['RBR','RBS','WRB','CC','VBD','EX
       ','VBN','NNS','NNP','.','TO','VBG','VBP','JJ','JJS','CD','VB
       ','PRP','MD','NN','JJR','DT','IN','WDT','WP','RP','VBZ','RB','
       POS','#','PRP$'], average=None) # for each label
867
868 test_f1_score = f1_score(path_true_list, path_predict_list,
```

```
       average='macro')
869 test_f1_score = f1_score(path_true_list, path_predict_list,
       average='micro')
870 test_f1_score = f1_score(path_true_list, path_predict_list,
       labels = ['RBR','RBS','WRB','CC','VBD','EX','VBN','NNS','NNP
       ','.','TO','VBG','VBP','JJ','JJS','CD','VB','PRP','MD','NN','
       JJR','DT','IN','WDT','WP','RP','VBZ','RB','POS','#','PRP$'],
       average=None) # for each label
871
872 accuracy_score(path_true_list, path_predict_list)  # overall
       accuracy
873
874
875 ##########################################
876 # Performance of NLTK's Baseline Tagger #
877 ##########################################
878
879 # load default_nltk_test_sentence_tagged
880 pkl_file2 = open('default_nltk_test_sentence_tagged.pkl', 'rb')
881 default_nltk_test_sentence_tagged = pickle.load(pkl_file2)
882 pkl_file2.close()
883
884 # True Path with Tag
885 path_true_tag_collection = []
886 for k in test_sentence_tagged:
887     path_true = []
888     for l in k:
889         path_true.append(l[1])
890     path_true_tag_collection.append(path_true)
```

```
891
892 # Predicted Path with Tag from NLTK
893 path_predict_tag_collection = []
894 for k in default_nltk_test_sentence_tagged:
895     path_nltk = []
896     for l in k:
897         path_nltk.append(l[1])
898     path_predict_tag_collection.append(path_nltk)
899
900 path_true_list = [item for sublist in path_true_tag_collection
       for item in sublist]
901 path_predict_list = [item for sublist in
       path_predict_tag_collection for item in sublist]
902
903 # Evaluation
904 nltk_precision_score = []
905 nltk_recall_score = []
906 nltk_f1_score =[]
907
908 # create collection of validation metric scores
909 nltk_precision_score = precision_score(path_true_list,
       path_predict_list, average='macro')
910 nltk_recall_score = recall_score(path_true_list,
       path_predict_list, average='macro')
911 nltk_f1_score = f1_score(path_true_list, path_predict_list,
       average='macro')
912
913 ##################################################
914 # ---- End of Model Training and Evaluation ---- #
```

```
915 ##################################################
916
917
918 ################
919 # Extract word #
920 ################
921
922 nltk.help.upenn_tagset() # get NLTK treebank tags for reference
923
924 # Define tags wanted
925 wanted = ['NN', 'NNS','JJ', 'JJR', 'JJS']
926
927 process_test_sentence = []
928 with open('Process_CarTesting.txt') as inputfile:
929     for line in inputfile:
930         process_test_sentence.append(line)
931
932 # Tokenize test sentences
933 test_sentence_tokenized = []
934 for i in process_test_sentence:
935     test_sentence_tokenized.append(nltk.word_tokenize(i.lower()))
936
937 # save image
938 output2 = open('test_sentence_tokenized.pkl', 'wb')
939 pickle.dump(test_sentence_tokenized, output2)
940 output2.close()
941
942 # load test_sentence_tokenized
943 pkl_file2 = open('test_sentence_tokenized.pkl', 'rb')
```

```
944 test_sentence_tokenized = pickle.load(pkl_file2)
945 pkl_file2.close()
946
947 # Find the position of corresponding word POS in each test
       sentence
948 wanted_index = word_index_extractor(wanted,
       path_predict_tag_collection)
949
950 # Extract word paired with index
951 wanted_word = word_extractor(wanted_index,
       test_sentence_tokenized)
952
953 # save image
954 output2 = open('wanted_word.pkl', 'wb')
955 pickle.dump(wanted_word, output2)
956 output2.close()
957
958 # load wanted_word
959 pkl_file2 = open('wanted_word.pkl', 'rb')
960 wanted_word = pickle.load(pkl_file2)
961 pkl_file2.close()
962
963
964 ######################################
965 # Extract sentences with expect word #
966 ######################################
967 # e.g. transmission/transmissions, quality, seat/seats/seating,
       style/styling, interior/interiors, exterior/exterior, gas/
       mileage/mpg/mpgs, engine
```

```
968
969 expect_word = ['transmission', 'transmissions']
970
971 expect_index = word_index_extractor(expect_word, wanted_word)
972
973 # Output summarized sentences that contain wanted words
974 expect_sent = expect_sentence(expect_index, wanted_word)
```