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

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Yue Ming

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Title

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

By

Yue Ming

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

DOCTOR OF PHILOSOPHY

SUPERVISORY COMMITTEE:

Gang Shen

Chair

Rhonda Magel

Curt Doetkott

Juan Li

Approved:

April 11, 2019

Rhonda Magel

Date

Department Chair
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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# TABLE OF CONTENTS

ABSTRACT .................................................................................. iii

ACKNOWLEDGEMENTS ................................................................. iv

LIST OF TABLES ................................................................. vii

LIST OF FIGURES ................................................................. viii

1. INTRODUCTION ............................................................. 1

2. RELATED WORK ............................................................ 3

3. PROPOSED FRAMEWORK ................................................. 5
   3.1. CRFs ........................................................................ 5
   3.2. Parameter Estimation .................................................. 7
   3.3. Dynamic Programming for CRF Probability as Matrix Computations ........ 8
   3.4. Training with Limited-Memory Quasi-Newton Method ................. 9
   3.5. Path Prediction with Viterbi Algorithm ........................... 10

4. EXPERIMENT ................................................................. 12
   4.1. Train the CRF POS Tagger ............................................ 12
   4.2. Performance Evaluation ............................................... 13
       4.2.1. Validation ......................................................... 15
       4.2.2. Testing ............................................................ 15
       4.2.3. Comparison ...................................................... 17

5. FEATURE EXTRACTION .................................................. 21

6. SUMMARY ................................................................. 23

REFERENCES ................................................................. 26
APPENDIX A.  PENN TREEBANK PART-OF-SPEECH TAGS ..................... 29
APPENDIX B.  CAR REVIEWS RAW DATA ................................. 31
APPENDIX C.  SOURCE CODE IN PYTHON FOR CRF IMPLEMENTATION ...... 75
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transformations</td>
<td>12</td>
</tr>
<tr>
<td>2. Validation Performance - Mean, Standard Deviation and 95% C.I.</td>
<td>15</td>
</tr>
<tr>
<td>3. Overall Performance - Precision, Recall and $F_1$</td>
<td>15</td>
</tr>
<tr>
<td>4. Performance on Individual Tags - Precision, Recall and $F_1$</td>
<td>19</td>
</tr>
<tr>
<td>5. Example: Tagging Output &amp; Comparison</td>
<td>20</td>
</tr>
<tr>
<td>6. Performance Comparison: CRF vs NLTK Baseline Tagger</td>
<td>20</td>
</tr>
<tr>
<td>7. Example: Word Extraction from Review Sentence</td>
<td>21</td>
</tr>
<tr>
<td>9. Different Types of Entities</td>
<td>23</td>
</tr>
<tr>
<td>10. Label with New Tags</td>
<td>24</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The Framework Pipeline</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Graphical Structure of A Chain-Structured CRFs for Sequences</td>
<td>6</td>
</tr>
<tr>
<td>3.</td>
<td>Convergence of Negative Log-Likelihood</td>
<td>13</td>
</tr>
<tr>
<td>4.</td>
<td>Distribution of Predicted Feature Weights</td>
<td>14</td>
</tr>
<tr>
<td>5.</td>
<td>Histogram of Performance Measures - Validation 200 Times</td>
<td>16</td>
</tr>
<tr>
<td>6.</td>
<td>Confusion Matrix</td>
<td>17</td>
</tr>
<tr>
<td>7.</td>
<td>Error Matrix</td>
<td>18</td>
</tr>
</tbody>
</table>
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 natural 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 sequential 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 linear-chain CRFs model; (4) applying the model to the test set and extract opinions.

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 1st order CRF \((X, Y)\) is specified by a vector \(F\) of local features and a corresponding weight vector \(\lambda\). 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
is the position of a token in the sequence. Figure 2 displays the graphical structure of a chain CRFs, where \( Y \) forms a simple 1st order chain. Here we define the 1st order features:

\[
X = X_1, \ldots, X_{t-1}, X_t
\]

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

- The assignment 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 \( F_k(y_t|y_{t-1}) = \mathbb{1}_{\{y_t = y'\}} \mathbb{1}_{\{y_{t-1} = y\}} \).

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 4th word [extremely] are defined by:

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

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

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

(1)

where

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

(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 $x$:

$$\hat{y} = \arg\max_y P(y|x)$$

(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 $x = x_1x_2, \ldots, x_T$ and it’s corresponding POS $y = y_1y_2, \ldots, y_T$, 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:

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

(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. $\sigma$ is assigned a Gaussian prior and the value of $\sigma^2$ 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:

\[
\frac{\partial \ell}{\partial \lambda_k} = \sum_{i=1}^{N} \left( \sum_{t=1}^{T_i} F_k(y_{t-1}^{(i)}, y_t^{(i)}, x_t^{(i)}) - E_{P(Y|x^{(i)})} F(Y, x^{(i)}) \right) - \frac{\lambda_k}{\sigma^2}
\]

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 \textit{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 \textit{start} and \textit{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 \(\{M_t(x)\mid t = 1, \ldots, t+1\}\), where each \(M_t(x)\) is a \(|\mathcal{Y}_{t-1}| \times |\mathcal{Y}_t|\) matrix with elements of the form:

\[
M_t(y', y|x) = \exp\left(\sum_k \lambda_k F_k(y_{t-1}, y_t, x, t)\right)
\]

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

\[
P(y|x) = \frac{1}{Z(x)} \prod_{t=1}^{T+1} M_t(y_{t-1}, y_t|x)
\]

The partition function \(Z(x)\) is given by the \((\text{start}, \text{end})\) entry of the product of all \(n+1\) \(M_t(x)\)
matrices:
\[ Z(x) = \left[ \prod_{t=1}^{T+1} M_t(x) \right]_{start,end} \]  \( (8) \)

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 \( \alpha_t \) and \( \beta_t \) starting with the base cases:

\[
\begin{align*}
\alpha_0 &= \begin{cases} 
1 & \text{if } y = \text{start} \\
0 & \text{otherwise} 
\end{cases} \\
\beta_{t+1} &= \begin{cases} 
1 & \text{if } y = \text{stop} \\
0 & \text{otherwise} 
\end{cases}
\end{align*}
\]  \( (9) \)

and for recurrence:

\[
\begin{align*}
\alpha_t(x) &= \alpha_{t-1}(x)^t M_t(x) \\
\beta_t(x) &= M_{t+1}(x) \beta_{t+1}(x)
\end{align*}
\]  \( (10) \)

Finally, the conditional probability can be written as:

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

which can thus be plugged into \textit{Equation (5)} to calculate the gradient.

\textbf{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 $\lambda_k$ 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 $\rho_k = \frac{1}{y_k s_k}$, and $H_k^0 = \frac{y_{k+1} s_k^T}{y_k}$ 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]:

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

- **2nd Loop:** Define another sequence of vectors where each element $z_i[z_{k-m}, \ldots, z_k] = H_i q_i$. The second recursion calculates $z_{k-m} = H_k^0 g_{k-m}$, thus obtains $b_i = \rho_i y_i z_i$ 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:

$$f(\lambda_k + \gamma_k d_k) \leq f(\lambda_k) + \sigma \cdot \gamma_k^\eta \cdot g_k^T d_k$$  \hspace{1cm} (12)

where $\gamma_k$ is the step size, $\sigma \in (0, 1)$ is a control parameter and $\eta$ 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 $\eta$ value, and then the $\gamma_k^\eta$ 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):

\[
V_1 = O_{y_1, x_1} \quad (13)
\]

\[
V_t = \max_{Y \in L}(O_{y_t, x_t} + A_{y_{t-1}, y_t}) \quad (14)
\]

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 \( P_{tr}(y_t, t) \) be the function that returns the value of \( y_t \) used to compute \( V_t \), then we have:

\[
y_T = \max_{Y \in L}(V_T) \quad (15)
\]

\[
y_{t-1} = P_{tr}(y_t, t) \quad (16)
\]
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

<table>
<thead>
<tr>
<th>Regular Expression</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>sub(r'(?![0-9])', ' ', ')</td>
<td>separate [i’m] to [i] and [’m]</td>
</tr>
<tr>
<td>sub(r'(?![A-Za-z])', ' '</td>
<td>remove ’ before numbers, e.g. [’0] to [0]</td>
</tr>
<tr>
<td>sub(r',(?![A-Za-z])</td>
<td>,(?!A-Za-z))', ' '</td>
</tr>
<tr>
<td>sub(r'[~!(]</td>
<td>[:;&quot;]+', ' ')</td>
</tr>
<tr>
<td>sub(r'[A-Za-z]+\d+</td>
<td>[A-Za-z]+\d+([A-Za-z]+)\d+\d+\d+', '#CarModel#')</td>
</tr>
<tr>
<td>sub(r'[d+\d+\d+\d+\d+\d+\d+', '#CarNum#')</td>
<td>replace number, e.g. [1000] with notation “#CarNum#”</td>
</tr>
</tbody>
</table>

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](chart.png)

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) → Noun (NN)] vs [Adjective (JJ) → 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):

\[
\text{Precision} = \frac{\text{TruePositive}}{\text{TruePositive} + \text{FalsePositive}} = \frac{\text{TruePositive}}{\text{TotalPredictedPositive}} \tag{17}
\]

\[
\text{Recall} = \frac{\text{TruePositive}}{\text{TruePositive} + \text{FalseNegative}} = \frac{\text{TruePositive}}{\text{TotalActualPositive}} \tag{18}
\]
and $F_1$ score is the harmonic mean of the precision and recall, which helps seek a balance between precision and recall:

$$F_1 = \frac{2}{\frac{1}{\text{Precision}} + \frac{1}{\text{Recall}}}$$  \hspace{1cm} (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>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>$F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.9423</td>
<td>0.9224</td>
<td>0.9202</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.0218</td>
<td>0.0212</td>
<td>0.0212</td>
</tr>
<tr>
<td>95% C.I.</td>
<td>[0.9393, 0.9453]</td>
<td>[0.9195, 0.9253]</td>
<td>[0.9173, 0.9231]</td>
</tr>
</tbody>
</table>

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 further model tuning is required 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>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>$F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>0.9322</td>
<td>0.9290</td>
<td>0.9264</td>
</tr>
<tr>
<td>Micro</td>
<td>0.9352</td>
<td>0.9352</td>
<td>0.9352</td>
</tr>
</tbody>
</table>

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.
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 5. Histogram of Performance Measures - Validation 200 Times
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 comparison is displayed in Table 6. The performances of the two competing
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 $F_1$

<table>
<thead>
<tr>
<th>POS Tag</th>
<th>Precision</th>
<th>Recall</th>
<th>$F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBR</td>
<td>0.8333</td>
<td>0.7143</td>
<td>0.7692</td>
</tr>
<tr>
<td>RBS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>WRB</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CC</td>
<td>0.9828</td>
<td>1</td>
<td>0.9913</td>
</tr>
<tr>
<td>VBD</td>
<td>0.8636</td>
<td>0.7917</td>
<td>0.8261</td>
</tr>
<tr>
<td>EX</td>
<td>0.6667</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>VBN</td>
<td>0.85</td>
<td>0.7727</td>
<td>0.8095</td>
</tr>
<tr>
<td>NNS</td>
<td>0.8205</td>
<td>0.9412</td>
<td>0.8767</td>
</tr>
<tr>
<td>NNP</td>
<td>0.8864</td>
<td>0.9512</td>
<td>0.9176</td>
</tr>
<tr>
<td>.</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TO</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VBG</td>
<td>0.9091</td>
<td>0.6667</td>
<td>0.7692</td>
</tr>
<tr>
<td>VBP</td>
<td>0.875</td>
<td>0.9333</td>
<td>0.9032</td>
</tr>
<tr>
<td>JJ</td>
<td>0.8831</td>
<td>0.9067</td>
<td>0.8947</td>
</tr>
<tr>
<td>JJS</td>
<td>0.8571</td>
<td>0.8571</td>
<td>0.8571</td>
</tr>
<tr>
<td>CD</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VB</td>
<td>0.8235</td>
<td>0.7</td>
<td>0.7568</td>
</tr>
<tr>
<td>PRP</td>
<td>1</td>
<td>0.9792</td>
<td>0.9895</td>
</tr>
<tr>
<td>MD</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NN</td>
<td>0.9207</td>
<td>0.9289</td>
<td>0.9248</td>
</tr>
<tr>
<td>JJR</td>
<td>0.7692</td>
<td>1</td>
<td>0.8696</td>
</tr>
<tr>
<td>DT</td>
<td>0.9896</td>
<td>0.9896</td>
<td>0.9896</td>
</tr>
<tr>
<td>IN</td>
<td>0.9355</td>
<td>0.9775</td>
<td>0.9560</td>
</tr>
<tr>
<td>WDT</td>
<td>1</td>
<td>0.75</td>
<td>0.8571</td>
</tr>
<tr>
<td>WP</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RP</td>
<td>1</td>
<td>0.8333</td>
<td>0.9091</td>
</tr>
<tr>
<td>VBZ</td>
<td>0.9855</td>
<td>0.9067</td>
<td>0.9444</td>
</tr>
<tr>
<td>RB</td>
<td>0.8644</td>
<td>0.7612</td>
<td>0.8095</td>
</tr>
<tr>
<td>POS</td>
<td>0.6</td>
<td>0.75</td>
<td>0.6667</td>
</tr>
<tr>
<td>#</td>
<td>1</td>
<td>0.8333</td>
<td>0.9091</td>
</tr>
<tr>
<td>PRP$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 5. Example: Tagging Output &. Comparison

<table>
<thead>
<tr>
<th></th>
<th>The car is roomy inside, comfortable, handles and performs great and is fun to drive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original sentence</td>
<td>the car is roomy inside comfortable handles and performs great and is fun to drive</td>
</tr>
<tr>
<td>True Path</td>
<td>DT NN VBZ JJ IN JJ VBZ CC VBZ JJ CC VBZ JJ TO VB</td>
</tr>
<tr>
<td>Predicted Path</td>
<td>DT NN VBZ JJ RB JJ VBZ CC VBZ JJ CC VBZ JJ TO VB</td>
</tr>
</tbody>
</table>

Table 6. Performance Comparison: CRF vs NLTK Baseline Tagger

<table>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>( F_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRF</td>
<td>0.9322</td>
<td>0.9290</td>
<td>0.9264</td>
</tr>
<tr>
<td>NLTK Baseline Tagger</td>
<td>0.9248</td>
<td>0.9210</td>
<td>0.9201</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Original sentence</th>
<th>The car is roomy inside, comfortable, handles and performs great and is fun to drive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processed sentence</td>
<td>the car is roomy inside comfortable handles and performs great and is fun to drive</td>
</tr>
<tr>
<td>Predicted Path</td>
<td>DT NN VBZ JJ RB JJ VBZ CC VBZ JJ CC VBZ JJ TO VB</td>
</tr>
<tr>
<td>Extracted words</td>
<td>car roomy comfortable great fun</td>
</tr>
</tbody>
</table>

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]:

| 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]:

| 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 JJ CC VBZ JJ TO VB |

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.
REFERENCES


## APPENDIX A. PENN TREEBANK PART-OF-SPEECH TAGS

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td>dollar</td>
<td>$ -$ –$ A$ C$ HK$ M$ NZ$ S$ U.S.$ US$</td>
</tr>
<tr>
<td>“</td>
<td>opening quotation mark</td>
<td>“ “</td>
</tr>
<tr>
<td>”</td>
<td>closing quotation mark</td>
<td>” ”</td>
</tr>
<tr>
<td>(</td>
<td>opening parenthesis</td>
<td>( [ {</td>
</tr>
<tr>
<td>)</td>
<td>closing parenthesis)</td>
<td>) ] }</td>
</tr>
<tr>
<td>,</td>
<td>comma</td>
<td>,</td>
</tr>
<tr>
<td>–</td>
<td>dash</td>
<td>–</td>
</tr>
<tr>
<td>.</td>
<td>sentence terminator</td>
<td>. ! ?</td>
</tr>
<tr>
<td>:</td>
<td>colon or ellipsis</td>
<td>: ; ...</td>
</tr>
<tr>
<td>CC</td>
<td>conjunction, coordinating</td>
<td>&amp; ’n and both but either et for less minus neither nor or plus so therefore times v. versus vs. whether yet</td>
</tr>
<tr>
<td>CD</td>
<td>numeral, cardinal</td>
<td>mid-1890 one-tenth million 0.5 one 1987 ’79 IX ’60s .025 271,124 dozen quintillion DM2,000 ...</td>
</tr>
<tr>
<td>DT</td>
<td>determiner</td>
<td>all an another any both del each either every half la many much nary neither no some such that the them these this those</td>
</tr>
<tr>
<td>EX</td>
<td>existential there</td>
<td>there</td>
</tr>
<tr>
<td>FW</td>
<td>foreign word</td>
<td>gemeinschaft hund ich jeux habeas Herr K’ang-si vous luthaw alai je jour fille ...</td>
</tr>
<tr>
<td>IN</td>
<td>preposition or conjunction, subordinating</td>
<td>astride among uppon whether out inside pro despite on by throughout ...</td>
</tr>
<tr>
<td>JJ</td>
<td>adjective or numeral, ordinal</td>
<td>third ill-mannered pre-war regrettable ...</td>
</tr>
<tr>
<td>JJR</td>
<td>adjective, comparative</td>
<td>cheaper choosier cleaner ...</td>
</tr>
<tr>
<td>Tag</td>
<td>Description</td>
<td>Examples</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>JJS</td>
<td>adjective, superlative</td>
<td>cheapest choicest classiest ...</td>
</tr>
<tr>
<td>LS</td>
<td>list item marker</td>
<td>A A. B B. First G H I ...</td>
</tr>
<tr>
<td>MD</td>
<td>modal auxiliary</td>
<td>can cannot could couldn’t dare may might must need ought shall should shouldn’t will would</td>
</tr>
<tr>
<td>NN</td>
<td>noun, common, singular or mass</td>
<td>cabbage knuckle-duster Casino ...</td>
</tr>
<tr>
<td>NNP</td>
<td>noun, proper, singular</td>
<td>A.K.C. Meltex Liverpool ...</td>
</tr>
<tr>
<td>NNPS</td>
<td>noun, proper, plural</td>
<td>Americans Americas ...</td>
</tr>
<tr>
<td>NNS</td>
<td>noun, common, plural</td>
<td>undergraduates scotches ...</td>
</tr>
<tr>
<td>PDT</td>
<td>pre-determiner</td>
<td>all both half many quite such sure this</td>
</tr>
<tr>
<td>POS</td>
<td>genitive marker</td>
<td>'s</td>
</tr>
<tr>
<td>PRP</td>
<td>pronoun, personal</td>
<td>hers herself ownself self she ...</td>
</tr>
<tr>
<td>PRPS</td>
<td>pronoun, possessive</td>
<td>her his mine my our ours their thy your</td>
</tr>
<tr>
<td>RB</td>
<td>adverb</td>
<td>occasionally unabatingly ...</td>
</tr>
<tr>
<td>RBR</td>
<td>adverb, comparative</td>
<td>further gloomier grander ...</td>
</tr>
<tr>
<td>RBS</td>
<td>adverb, superlative</td>
<td>best biggest bluntest ...</td>
</tr>
<tr>
<td>RP</td>
<td>particle</td>
<td>aboard about across along ...</td>
</tr>
<tr>
<td>TO</td>
<td>”to” as preposition or infinitive marker</td>
<td>to</td>
</tr>
<tr>
<td>UH</td>
<td>interjection</td>
<td>Goodbye Goody Gosh Wow ...</td>
</tr>
<tr>
<td>VB</td>
<td>verb, base form</td>
<td>ask assemble assess ...</td>
</tr>
<tr>
<td>VBD</td>
<td>verb, past tense</td>
<td>dipped pleaded swiped ...</td>
</tr>
<tr>
<td>VBG</td>
<td>verb, present participle or gerund</td>
<td>telegraphing stirring focusing ...</td>
</tr>
<tr>
<td>VBN</td>
<td>verb, past participle</td>
<td>multihulled dilapidated ...</td>
</tr>
<tr>
<td>VBP</td>
<td>verb, present tense, not 3rd person singular</td>
<td>predominate wrap resort ...</td>
</tr>
<tr>
<td>VBZ</td>
<td>verb, present tense, 3rd person singular</td>
<td>bases reconstructs marks ...</td>
</tr>
<tr>
<td>WDT</td>
<td>WH-determiner</td>
<td>that what whatever which whichever</td>
</tr>
<tr>
<td>WP</td>
<td>WH-pronoun</td>
<td>that what whatever whatsoever which who whom whosoever</td>
</tr>
<tr>
<td>WP$</td>
<td>WH-pronoun, possessive</td>
<td>whose</td>
</tr>
<tr>
<td>WRB</td>
<td>Wh-adverb</td>
<td>how however whence whenever where whereby whereever wherein whereof why</td>
</tr>
</tbody>
</table>
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 it 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: 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 at least 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.
Surprisingly agile for a 4 cyl, auto transmission requires manual downshift for quick instant power.

While driving on the interstate with the window down, the wind makes an annoying sound as it bounce against the interior of the car.

Although it is fun to drive and quality seems ok, the leather seats are very uncomfortable, especially on a long drive.

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.

Has lots of features, is comfortable, everything works.

It can occasionally accelerate quickly and jerk you ahead, or hesitate, and sometimes I’ve noticed the car slow down unnaturally via the transmission.

The two door coupe is very comfortable and roomy and draws plenty of attention.

Additionally, the standard seats are not my favorite.

Extremely comfortable with 3 separate power driver seat adjustments.

00 per gallon I wanted something more fuel efficient but large enough to seat four adults comfortably and provide a sense of safety too.

The seat is extremely uncomfortable.

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!

The driver’s seat is very uncomfortable.

Nowhere near the mileage the sticker shows.

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.

The head rest tills forward which pushes the driver’s head forward at a very uncomfortable position.

The front driver seat’s lumbar support seemed very uncomfortable at first.

Its ride, comfort and overall performance is an absolute joy.

The car is comfortable and QUIET.

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.

No big deal The car is huge and very comfortable.

Very tight, runs great, very comfortable to drive.

The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats.

Initially the dashboard controls were a little intimidating, but
it doesn’t take long to get comfortable with them.

I fit in the Coupe comfortably.

The driver seating is uncomfortable.

It’s a comfortable ride and is very high quality.

For a 4 cylinder car I am surprised at the comfortable and peppy drive.

This a good choice if you need an affordable and comfortable commuting vehicle but hate the idea of a boring boxy sedan.

What a car, design, ride, comfort, 270 watt audio system, I love this car.

The seats are very comfortable & supportive.

I like my Accord very much, but had I known the drivers seat was so uncomfortable I would have never bought it.

Aside from missing the turbo’s acceleration, I’ve preferred the Accord’s better mileage, handling and comfort.

This Accord is the only large car I found with upscale comfort amenities and a good manual transmission.

Comfort inside is better than expected.

My family of 5 can comfortably ride in this car.

This car is a dream from the GAS to the STYLE to the COMFORT.

It’s the most comfortable Accord I have had.

I do find the lumbar on the driver’s seat a bit uncomfortable though.

The car is very comfortable, the steering is tight and precise.

The seats are comfortable, and there is ample leg room in the front and rear.

Most uncomfortable seats in any vehicle I have ever owned.

It is very comfortable, easy to drive and park.

I would recommend this car for great value, comfort, & fun to drive!

Seats are firm but not uncomfortable, very BMW like.

I’ll probably sell it to avoid an expensive transmission repair after the extended warranty expires.

Rides with comfort and motor will pick up if you need it.

It gives a sporty driving feel and offers a very comfortable Highway ride.

Uncomfortable in Camry, Had a Nissan before, rough ride.

Test drove Honda and enjoyed the firm yet very comfortable ride.

It’s very comfortable, has pretty much every luxury feature you might want, and is still fun to drive.

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.

Seats are very comfortable and ride is very smooth!

My only complaint is comfort.

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. However, the 08 Accord is well designed, handles well for its size and the comfort level is so much better than the TL. Absolutely got a great car, roomy, comfortable, great ride for a nice price.

Fun to drive, safe, reliable, and comfortable.

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

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

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

Driving 55 miles per hr between Houston and Austin this slow is very painful, boring to drive, 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.

At 6’5 it is very comfortable.

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

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.

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

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

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

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.

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

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

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

Door closure is solid, leather seats are very comfortable.

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.

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

Lots of room and very comfortable.
I purchased this car because the amount of time I spend on the road, I need a comfortable car that is reliable.

This car is comfortable, loaded with options and every one that gets into it loves it.

Seats are not very comfortable and not happy with the heated seats.

The seats are very comfortable and I love the cloth.

The Accord has looks, comfort, great ride and reliability.

Ample room for someone that is 6'2, and extremely comfortable for my daily commute.

An extremely comfortable and capable sedan.

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.

I went for comfort over performance to fit it in my budget so the EX, L with the 4 cyl engine.

So far, the reliability has been as expected, it is comfortable on my back, and the gas mileage has been pretty good.

The interior design is roomy and very comfortable.

Steering nice and tight, seats a little stiff but comfortable.

Interior is very roomy, and I can sit comfortably in the rear seat at 6'2.

Great car, really comfortable and quiet.

Solid build, comfortable interior, smooth ride, fuel efficient averaging 27.

This is my second Accord and it's bigger, zippier and more comfortable.

This car is stylish and very comfortable to drive.

It is comfortable, easy to drive, and fast!

Very comfortable and roomy vehicle.

The ride is firm but not harsh, It is more comfortable than the Maxima and looks much better than any Camry.

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.

Fun to drive, economic, very comfortable, and excellent on the highway.

It's much more comfortable than the Vette and I absolutely love driving it.

It has great handling and does so with comfort.

Have to say the comfort, look, design and how it drives is first rate.

Back seat comfort and entry exit are great.

Ride is superior, comfortable seats, radio excellent.

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.
The ride is loud and not comfortable.

I drive 2 hours to work each day and it is just not comfortable to me.

Getting about 26 mpg mixed city hwy with conservative driving, seating 4 people comfortably.

The ride is quiet and comfortable.

Styling is bland, the engine isn’t strong at all, and the car doesn’t deliver good comfort while driving it.

The seats aren’t comfortable either.

It is relatively comfortable inside.

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.

The driver seat is still soft and mostly uncomfortable.

The ride is comfortable and it seems to ride a little higher than the average sedan, which I like.

I’ve had 3 BMWs and only one of them could offer a more comfortable ride than the Camry.

Second the internal comfort is awful.

The previous soft seats were replaced with hard cheap ones which are very very uncomfortable and give me back pain.

If you keep in mind that the Camry is a comfort car, you may even enjoy the experience.

While the 4 cylinder does not have the punch of the Honda Accord 4 cylinder, the comfort and quietness of the ride won out.

No hesitation, comfort is great in front in back.

I feel uncomfortable driving this car and will get rid of it.

Very comfortable, great styling.

I was surprised by how quiet the cabin was and just how comfortable it was to sit in and drive.

This car offers poor driver’s seat comfort, poor vision, only average ride quality, gas mileage.

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.

I’d highly recommend anyone buy this car if they are seeking an affordable, comfortable, reliable vehicle.

You can not get that comfort with any other automaker other than perhaps Honda.

Looks are great and interior is comfortable, but it?

I needed a comfortable commuter that I could also run around with the family in.

Great ride, quiet comfortable spacious cabin, superior electronics, fair price and good looks.

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.

The interior is very luxurious and comfortable, however the car feels slower than my 2002 Camry LE.
For the comfort and entertainment of the ride, I like the Camry.

The driver’s seat is really comfortable.

I have had no transmission issues or rattling, the comfort and ride of this vehicle felt to me much more high end than what I had paid.

I love the look, and the comfort, but would never buy one again.

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.

The seats were very comfortable.

The car comfort, looks, performance and fuel economy are great but the paint is a disaster.

Front seats are not comfortable on long trip.

I was not sure at first about trading my 01 Honda Accord but have been more than satisfied with the performance, looks, and comfort.

A little stiffer ride than the xl and xle models I have had, but still comfortable and quiet.

Very comfortable ride and seating.

Very low interior noise level, which adds to the long trip comfort.

The ride, comfort, and drive is as expected, however, the quality and reputation of yore are completely gone for the flagship Camry.

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.

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.

Very comfortable, quiet interior.

Seats are padded more firmly than previous model but comfortable on trips.

Feels expensive, yet comfortable with larger interior than my Grand Prix.

Trunk is big and rear seat very comfortable for 2 and will seat 3.

Headroom body room comfort great for my 6’1 250 lbs.

I feel that the Camry just gets better and better in terms of comfort, styling and performance with each generation.

It looks awesome, turns like it’s on rails, has a great sound system, and is just comfortable and fun to drive.

It is very quiet and comfortable.

Smooth, comfortable, reliable, fast.

Very comfortable seating position for both me and my husband.

The interior is extremely comfortable, and spacious.

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.
The seats were very comfortable on a four and a half hour trip, and wind and road noise were minimal.

The interior is much more comfortable than my last 3 Camrys and the exterior styling is oh so chic.

Comfortable and quiet with excellent gas mileage.

Comfort is great, mileage is good overall, better on the road than expected, compared to my 1999 Camry.

Having flown 26 different aircraft and driven cars for 61 years, I find the 2007 Camry to be the most uncomfortable cockpit I have ever been in.

The headrest presses into my head at an uncomfortable angle and it is impossible to tell where the front of the car is for parking.

The window sill is too high and the armrest too low to be comfortable.

The new looks are what attracted it to me initially, but its relatively smooth drive, comfort and reliability sold me on it.

It is a beautiful sapphire blue, has really nice lines, is very comfortable, is plenty peppy, and hugs the road.

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.

It is so comfortable and drives perfect.

Overall this car is very quiet, comfortable, smooth, powerful, and absolutely the best mid-size in the current market.

Leather seats are comfortable, Nav system is easy to use.

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.

Ride seems comfortable and gas mileage fairly good averaging 26 city and 30 open road.

It gets great gas mileage.

Being a mother who drives a lot I wanted a safe vehicle with good gas mileage and this car delivered that and more.

Great gas mileage and comfortable on long trips.

Nice looking car and good gas mileage.

Good gas mileage, comfortable seating, lots of leg room.

The interior is roomy, the ride is smooth and solid and yet it has excellent gas mileage.

The gas mileage is still good, can’t give specifics but for a V6, its good.

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.

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 windshield 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.
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.

throttle hesitation, and poor gas mileage.

My previous BMW 3 series got better mileage, and believe me it was more fun to drive.

We have become Toyota Camry and Honda Accord lovers driving used high mileage models from 1992, 1994.

The Mileage Queen has put 55,000 miles on Ricky since Sept 06.

truly fantastic gas mileage.

Gas mileage now is in the high 20s and that should improve with time.

The delay in acceleration and poor mileage makes this car worse than any other car in the segment.

Mileage a little disappointing.

The gas mileage has been getting better.

I first averaged 23 mpg during the break in period, but ever since then the mileage have increased slowly.

Highway mileage is 29, which I consider poor for a 4, cylinder.

Gas mileage is poor, 25 mpg.

Highway mileage already greater than promised.

Appears to have good mileage.

Wish it delivered the gas mileage of my 2003 XLE.

This car has it all, styling, performance, durability, wonderful gas mileage and just a great and exciting car to drive.

The V6 was too much power, but with the gas mileage difference of less than 2 MPG.

Gas mileage is disappointing, 21 in town.

The mileage seems to be good too as the fuel indicator still shows approx.

Can’t beat the room, gas mileage and performance for dollar.

Good acceleration for engine size, and good mileage, especially when highway cruising around 70 mph.

I drove the car 600 miles in the last week and gas mileage averaged 26 mpg.

Gas mileage on recent long trip was a disappointing 28, 29 mpg.

This car has plenty of pick up and go even with the in line four cylinder engine along with good gas mileage and handling.

Serious disappointment in gas mileage, particularly over my previous 1999 model.

Gas mileage on the first tank was 30.

I am a little disappointed with the mileage but I do have a tendency to drive more aggressive in the model.

2000 miles were on a trip north on I, 95 the rest of the mileage was in Daytona Beach, FL and surrounding area.

on my 2000 mile trip gas mileage in Florida, Georgia, and South Carolina was 32.
7, as I edged into the mountains of NC and Virginia, the mileage fell to 30.

In town driving the mileage has been 20.

Would like to see better gas mileage too.

I am disappointed with the gas mileage.

It floats on the road, handles like it’s heavy and substantial, but I get great gas mileage, around 30 mpg.

Great ride, engine, interior, gas mileage.

Nice gas mileage for a family car.

Great performance, great gas mileage, superior quality, I always thought of a Camry as just a practical family sedan.

I got 35 highway mileage with ac on and combined 28-29 mile per gallon with ac on.

I purchased this camry, three weeks ago, acceleration is a major problem, just not like the older models of camry, was in an 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.

I would highly recommend this car. If your looking for a sporty, roomy, 4 door sedan with good gas mileage.

Safety was #1 and mileage was #2.

Traded my Highlander for it for better mileage w gas prices so high.

I decided on the Camry because of the value and gas mileage.

Biggest disappointment is gas mileage.

I actually get better highway mileage than sticker show.

I have to say the car rode great, comfortable and gas mileage great.

My mileage is 1.2 road and 1.2 city and I am averaging between 26, 28 mpgs.

I believe after it has some miles on it, the mileage will improve.

Gas mileage is lower than my '02.

The mileage has been both street and interstate, averaging 24 miles per gallon.

For a 4 cylinder engine what get, up and go, not to mention the great gas mileage.

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.

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.

Comfortable and quiet with excellent gas mileage.

Love the looks, power, roomy interior, good mileage at 32 hwy and
I like how it looked when I got the car, but with high gas prices, I am very disappointed with the gas mileage.

I thought great mileage & I loved the look of the new Camry.

If I’m going to get mileage this bad I may as well look good doing it.

My old 1989 Camry is still running well giving great mileage.

Mileage is mediocre at an average of 25.

The 4 cylinder does not get good mileage at 70 MPH plus.

Below it you can expect to get good mileage only if you do not have too many hills.

This car is easy to drive, great gas mileage and comfortable.

Doesn’t anyone build a quiet car out there for around 30K that used regular gas and gets good gas mileage?

I love the new body style and the interior is a simple pleasure except for the center dash.

However, there are a couple of things that kill it for me: terrible driver seat comfort, kills my back. Lack luster interior design, my Acadia has much better comfort. The VCM drives me crazy because the constant change in cylinder use is perceptible enough to be an annoyance.

Love the interior and the power and speed, but not hard to beat after what I had.

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.

The seats are decent, the interior design is excellent IMO as well as the exterior design, and thus far it has been extremely reliable.

The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats.

The interior design was much nicer.

The interior is nicely equipped and I like the XM radio but not the monthly fee.

The new styling is very upscale, and the interior layout is also impressive and spacious inside.

My only reservations are the ivory cloth interior’s durability had to have taffeta white!

Nice car, add’l $$ for premium gas, not as big of interior as accord, dealer that we would utilize for service not clean.

I don’t like the dash radio assembly, but the interior has a luxury look.

Only needs to add drivers seat memory, 2, tone perforated leather, xenons, rear seat interior illumination mounted under front seats, and better tilt.

Biggest plus I think is the roominess of the interior and the trunk.

The ride is very good The interior is awesome.
My car is taffeta white and I wish there was another interior color option other than ivory!

However after checking out the ’09 Camry, I was disappointed with the quality of the interior and outdated dash.

I like the interior space, dash, board, and a very functional cabin.

I have the diamond white pearl which is awesome with the tan interior.

Fun to drive, lots of power, smooth and a great interior.

The interior room is enormous.

The interior was boring and felt like a 5 year old design.

Interior very high end, exterior very upscale look.

Interior and exterior design is attention getting.

The interior is laid out great, appreciate the large screen, touch controls on the steering wheel.

The interior and exterior are nice.

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?

I hate to admit that they have loud interiors.

The exterior and interior is more reflective of European styling and it looks amazing.

The interior is huge and the exterior is super sleek.

The interior has loud vibrating squeaking rattles coming from the glove box.

Still enjoy interior and exterior styling as well as overall performance and handling.

The interior is really noisy unless the road surface is smooth.

Yes, it is roomy, has a nice interior, silky smooth engine, good transmission and direct steering.

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.

The Accord’s interior look and feel great.

Interior is superb, exterior is very stylish.

The new body style looks great, and the interior is laid out very well.

User friendly interior design.

I got the dark blue Accord with simonize paint and interior.

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.
Excellent pickup and great interior.

Most of the interior layout has been carefully thought out.

Impressed by the headlamps and the interior layout.

The black leather seats feel a bit hot on the back in the warm weather but otherwise no complaints about the interior.

The interior design is roomy and very comfortable.

Interior is very roomy, and I can sit comfortably in the rear seat at 6'2.

Good trunk space, nice finish and materials in both the interior and exterior.

Solid build, comfortable interior, smooth ride, fuel efficient averaging 27.

The interior and exterior are nice.

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.

Great interior room, Great safety features, and a great deal.

Everything is extremely well engineered and designed from the interior to the exterior to the engine compartment, etc.

Nicer interior than the Mercedes C300’s we looked at.

I completely disagree with experts saying that the new Honda Accord’s interior is of good quality.

Handles great, awesome fresh interior, lots of cool new features.

I love the amount of interior room of this car.

Great ride, roomy interior, legendary Honda reliability.

Eye catching appeal fit and finish exterior interior safety features laudable audio system good esp w XM radio interior room spacious 3.

Finally in November the dealer traded for a car just like the one I wanted except it had a different color interior.

Awesome interior with great comfort.

The new body styling is a big plus and the interior has the look of a more expensive vehicle.

The interior is tight and well put together.

High Honda quality interior materials, great stereo, and loaded with every option you could think of.

The interior is luxurious and large.

Interior is nice but not as comfortable as past Accords and feels a little cheap.

I am extremely satisfied after the first week though it was more costly, I still like the smooth power and handling of the V6, the comfort of the leather interior, and something new for me.

The interior design and the performance of the V6 are the highlights.

The interior room is plentiful.

Almost the entire interior of the car can be controlled by voice.
commands such as temp.

Black leather interior is very classy and plastic trim is nice.

The interior is plenty spacious and once I mastered all the controls and settings, they were easy enough to operate.

The interior is very similar to that of the TL, but for about $7k less.

I did not like the interior door moldings that covered the door controls.

Wish the colors were better with matched with the interior and exterior colors offered.

From the overall exterior styling, the leather interior, dashboard, moon roof, engine, wheels, tires, and even the trunk you get nothing less than quality.

The interior is comfortable, neat and you can find everything within reach.

The interior is roomy, exterior is definitely better than BMW 3 series.

Although it’s a lower trim level, it has high quality interior trim very comfortable seats and and very smooth, quiet ride.

The interior and exterior look great!

I love the interior layout and comfort.

First of all, the interior has way too many cheap plastic parts like the cheap plastic center piece that houses the clock.

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.

Insanely cheap plastic all over interior.

Disappointed in interior and exterior quality.

I love the color of the exterior and interior.

This car is nearly perfect when compared to other cars in this class regarding interior dimensions, visibility, exterior styling, etc.

Several parts in the interior rattle including the sunroof and some parts of the dash, the radio randomly will eject CDs, etc.

The interior is roomy, the ride is smooth and solid and yet it has excellent gas mileage.

The interior looks good but feels cheap compared to my 1997 LE camry.

The interior is large, the controls are well placed and simple.

Interior noise level is unacceptable, this is one noisy car on the freeway.

I love the exterior, but the interior is nothing to brag about.

The interior could use some work to make it not so cheap and plastic looking.

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.

The interior looks great to me.

This interior is as good or better than others in it’s class.

The interior is stylish, roomy and has many nice features.

Poor craftsmanship on interior.

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.

all combine to paint a less than luxerious interior.

Only thing would like to see is that the interior be made more available in the darker in the SE.

I love everything about my Camry, except for the interior looks, very cheap and the non alloy rims are very cheesy or cheap.

The car also does not allow fresh air through the vents if the AC isn’t on, the interior becomes very warm, very quickly.

Looks are great and interior is comfortable, but it?

Even the interior has not held up along with the awful wind noise at highway speeds.

The controls were installed without a problem no cutting of interior plastic, the knee airbag was bypassed.

Interior looks OK but is built a little cheap.

The interior is so very quiet, you must compare this car to a Cadillac.

The interior is very luxurious and comfortable, however the car feels slower than my 2002 Camry LE.

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.

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.

Interior quality is very poor.

Fit and finish are exquisite, the interior is extremely well designed, looks good, fun to drive.

Sound system is excellent and interior was adequate but the room is awesome!

The interior feels that of a Lexus or BMW and the exterior is an eye catcher.

I love its Avalon like roomy interior and great looks.

I love the interior lighting.

The exterior and interior are nice.

Like the looks and styling, both interior and exterior.

Interior exterior quality is very good.

It is a good interior and exterior design and should be copied by other car makers, but the MPG for the 2.

Very low interior noise level, which adds to the long trip comfort.
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.

The Camry has a ton of style and lots of interior room without being to bulky on the outside.

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.

Horrible quality of interior.

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.

The interior is very roomy and spacious and Toyota has given some nice standard features in LE.

The interior design is excellent.

Interior is very nice and quiet.

Very comfortable, quiet interior.

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.

Feels expensive, yet comfortable with larger interior than my Grand Prix.

I love the body style and the interior.

Exterior reminds me of a 530i and the interior is plush especially with the light woodgrain finish.

The interior is on par with other cars in its class, but not up to the fit and finish of previous Camrys.

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.

The interior is top notch and the navigation system is very intuitive.

Customizable features which don’t require dealer help like some brands auto lock modes, interior light modes, etc.

Interior is simple and well laid out.

The blue neon center console makes the interior look really cool, every single person that’s been in my car loved it.

The interior is extremely comfortable, and spacious.

I love the lighting on the radio controls, and the material on the interior, very soft and stylish.

Interior is very nice and much improved.

Practicality, good interior space, easy to get in and out of including putting an infant in a car seat.
Interior materials are far better than my old Mazda and V6 power is nuts.

I get positive comments each day on the exterior interior design.

I bought this car smitten by its exterior look and interior comfort.

The interior is classy, the standard MP3 is useful, the host of curtain bags and standard features add to the plus.

The new design is very aggressive on Toyota’s part and the interior design is very contemporary.

The ride is quieter, the car faster, the exterior and interior looks better.

The interior is nice and roomy and the exterior design is beautiful.

Great ride, engine, interior, gas mileage.

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.

The sunroof actually comes down and slides between the exterior and interior thus minimizing wind noise at speed.

The leather interior is worth the money.

Luxurious interior, great MP3 player addition.

The interior is fairly pleasant but suffers from too much hard plastic and some poor fits!

The interior is very quiet at highway speeds.

The cloth interior is great and the 4 cylinder has tons of power for such a small engine.

On top of that some interior trim pieces didn’t match and one fell off!

Smooth and responsive interior is as luxurious as you can get without slapping an L on the grill.

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.

The ride is refined, steering is tight, plenty of interior space, the exterior design is refreshing to look at.

My only complaint with the interior is the color of the fake wood:

The interior is much more comfortable than my last 3 Camrys and the exterior styling is oh so chic.

It’s quiet, get good gas mileage and looks clean inside and out.

The mileage is great, and I’ve had to get used to stopping less for gas.

Thought gas mileage would be better.

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.
I chose it for the low emissions, value for the money, reliability and gas mileage.

The EPA mileage ratings and what the dealer bragged about mileage wise are a joke.

6, 4, 3 eco engine has poor performance and gas mileage of 22 highway.

Road noise is horrible, stereo sucks, terrible gas mileage etc.

Otherwise the gas mileage, service intervals, drive and dependability is still pristine.

I traded an 05 Acura TL for the gas mileage savings.

Runs better than AUDI A6, Better Mileage

Gas mileage at first wasn’t great but having reached 2500 miles, it seemed to go up dramatically in city driving.

Leased in Feb 2008 as a replacement to a Pilot, which had poor gas mileage.

I do miss the carry and load capacity of the Pilot, but the Accord gets decent gas mileage by comparison.

My old Buicks had far smoother shifts at far higher mileage.

It has excellent gas mileage drove from PHX to San on a half a gas of tank.

gas mileage sucks, i was getting 20 mpg on 05 accord v6 and seem to pull only 18 mpg on this one.

Gas mileage is only 20 around town and 26 to 27 on the highway with a four!

The car has met expectations, aside from the gas mileage and wind noise.

Almost half the mileage as compared to advertisement.

At first the Gas mileage was very poor but has really improved.

I wanted an inexpensive car with good mileage, and strong resale.

Very good mileage, getting about 28 mpg combined highway, and I have a heavy foot.

The 190 hp I4 engine is powerful and smooth enough to enjoy, without sacrificing fuel mileage.

great mileage, poor build quality of the car.

On top of all this, I get horrible gas mileage in city driving I get 15, 16 mpg.

It gets great gas mileage and love the car.

Mileage over three tanks has been 25.

3 mpg as consistent full tank highway mileage.

The car drives great and gets better gas mileage than my 2000 Lincoln LS V8.

It looks great, handles well, and gets good gas mileage.

The gas mileage has improved from 18MPG to 21 but that still is not good.

Gas mileage has been a bit disappointing, but it has been improving.

the variable cylinder management changes to 4 cyl when not under
After owning a Honda Accord EX I had to go back to the Honda the gas mileage can’t be beat. Gas mileage is around 22, 23 in town and 29, 30 on the highway. Fuel mileage has been less than expected. It’s no 8 cylinder GT, but it also gets double the gas mileage and so far, no problems. Aside from missing the turbo’s acceleration, I’ve preferred the Accord’s better mileage, handling and comfort. The manual transmission lets me control the car better and achieve higher mileage. So beware, if you are trading in your V8 for a mileage vehicle, this is not it in my case. The car is getting great gas mileage even though I have only been driving it 2 weeks. Our 2008 Accord is very disappointing, our in town mileage is 14.

Gets great gas mileage, I mostly drive city and I am currently receiving 25. I just love the VCM makes the car give great mileage. Initial gas mileage looks good too. Don’t buy this car if you want good gas mileage. 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. My BMW 530i got better mileage. 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!

Fun to drive, fairly roomy, looks good, gas mileage is OK, but not as good as Honda advertises. Gas mileage is wonderful, 1st tank 26 mpg with almost all city driving. I had tons of room in my 4Runner, but I needed something that would get better gas mileage w/o giving up power. I am so very disappointed with the gas mileage! I traded for better mileage, and this is what I got. I will warn you though, that if you drive it like it should be driven, gas mileage isn’t the best.

It feels safe, performs well, looks fantastic and gets decent gas mileage for its size. The Accord is better than other those car on gas mileage and reliability. Strangely, the gas mileage is not as good as the Acura but is acceptable. Some reviewers were complaining about gas mileage. Gas mileage is horrible too, 20 mpg city highway after 6000 miles.
If you are looking for a car that is affordable and well built this is the car for you bad gas mileage.

In reality we have been very disappointed our in city mileage is 16, 17 and highway is better at 27.

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.

I am sure as gas prices go up cars will be built to get better mileage at the expense of acceleration.

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

I live in Chicago and drive downtown and back 2 times a week for school and am getting great mileage.

Only update is after about 5k miles the fuel mileage is less than I had anticipated.

Everything else such gas mileage, handling, stereo system is fine but it doesn’t make up for the loud rattles and wind noise.

It’s almost embarrassing driving such a nice car around a parking lot and have it sound like a high mileage beater.

So I saved $2 K upfront and will also save down the road since the 4 cylinder gets slightly better gas mileage.

It is a well built car that runs smooth and gets great gas mileage.

Gas mileage is still getting better though.

The gas mileage on the highway is about the same for both models.

Local mileage with the ’08 has been about 24 mpg, and about 25 mpg with the ’06’s that we’ve leased.

I decided to go back to Honda as even with high mileage they keep their value.

Mileage, also not impressive, all I can get is about 24mpg, far from the 32 mpg you see on the window sticker.

Posted mileage ratings are for those who have a heavy right foot.

Gas mileage is fantastic especially going from a V8 SUV to a 4 cylinder sedan.

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.

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.

190 hp and superior gas mileage.

It wasn’t worth saving the little difference in gas mileage for this Honda.

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.

The Gas mileage is good, the acceleration sometime is slow when
cold from 1st to 2nd gear.

I hope to get better mileage on extended highway trips.

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.

Gas mileage has been improving and is now consistently 29 hwy 22 city.

Very peppy engine great fuel mileage 28, 30 combined.

I am not known to drive slowly so I am pleased with the mileage.

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.

So far, the reliability has been as expected, it is comfortable on my back, and the gas mileage has been pretty good.

It is great to drive, has many nice features and gets you there with great mileage.

Mileage is very good and we have already taken it on a long trip.

I had rather not have it and sacrifice the mileage.

The gas mileage has been as advertised, hitting 32 mpg on the highway when driving at 65 MPH.

Gas mileage after 1000 miles is averaging apprx 23, 24 mpg in a blend of city highway.

It has everything but good gas mileage.

This car has great gas mileage even with the V6.

The best gas mileage I can get is 22 mpg which is mostly highway and the car sometimes hesitates during acceleration.

I drive around 60 miles a day so fuel mileage was important.

First tank mileage was 27 mpg not bad at all.

highway mileage slightly over 30 as advertised.

with gas prices, wanted better mileage.

It gets good mileage on HWY = 30 but mediocre on local = 21.

SUV, wanted something with better gas mileage and something that had good resale value.

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.

Gas mileage is disappointed, avg 20 mpg so far.

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.

At first the gas mileage was a disappointment, but as the car is now breaking in it's getting better.

I test the car and was very impressed with the looks and the 4cyl was adequate since gas mileage was very important to me.

I expected a little better gas mileage avg, approx 26 mpg.
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.

The ride is excellent, and the fuel mileage is impressive so far.

Wanted something with better handling and gas mileage.

Great gas mileage for a v, 6.

Gas mileage is horrible on highway at 21 mpg.

My mileage, is averaging about 28.

I was a bit disappointed with the 4 Cyl mileage as I drive over a 100 miles a day round trip to work.

There seems to be no way to shut it off and mileage is about 26 27 highway.

Mileage jumps on the highway to 31 32 at normal speeds.

The car is very smooth for a v4, my first, but I thought that the gas mileage should be More about 38, 45.

Around town gas mileage is not as good at 22 with a mix of city and high way.

Very happy with my 08 Accord, performance is quite adequate it has nice looks and is a great long, distance cruiser.

6, 4, 3 eco engine has poor performance and gas mileage of 22 highway.

Overall performance is good but comfort level is poor.

I’m impressed with the performance as well as efficiency gains.

It has room, performance, good MPG for its size and excellent reliability.

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!

Very happy with the car enjoy the ride and performance.

The performance of the engine is very smooth.

This car had rattles at 500 miles and has horrible performance even for a four cylinder.

Great performance and handling make this a real Winner!

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.

There seem to be so many components that enter into the VCM that performance can vary WIDELY from car to car.

Features, quality, reliability, and performance, at a price no other car maker can touch.

190 HP engine is a good compromise for performance and fuel economy.

I owned this car for only a week, but I am pleasantly surprised by its performance and build quality.

This car lacks the performance and handling of previous years.

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

Still enjoy interior and exterior styling as well as overall performance and handling.

I just put it on the highway this weekend and its performance was amazing!

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.

It fits right, is fun to drive, great stereo, fuel economy, performance.

If you want sports sedan handling and performance, then pay much more and buy a true sports sedan!

I went for comfort over performance to fit it in my budget so the EX, L with the 4 cyl engine.

I researched many other makes and models but for the performance, quality, and style, the accord won hands down for cars under $32,000.

Performance is outstanding, more like a sports car than a coupe.

Lots of power with the 6 spd, and the car has a great balance of style, performance, and reliability.

No problem with quality, performance, etc.

Engine performance is very lacking.

t anywhere close to 3 series on many facets, namely performance, but sadly to say, in others, it surpasses.

The 4 cylinder lacks performance and handling and the gas saving is only minimal.

The car is great, both with styling and performance.

I purchased a 2004 V6, Leather and I did not think Honda could do any better with design or performance.

I love the styling the performance and handling.

I was looking for a luxury, feel car with great performance at a good price.

Overweight, 3600 pounds, lots of road noise, and the combined performance of the VCM and the grade logic automatic transmission make this a miserable driver.

The interior design and the performance of the V6 are the highlights.

I was looking for a mid size coupe with style, performance and all season traction capability.

Styling in and out is fantastic, and the v, 6 performance is all one would hope for and more.

It does not diminish the performance of the car, it is just annoying.

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.

I previously owned a Toyota 4Runner which had incredible build
I bought the Camry because of Toyota reliability and quality.

I purchased a 2007 Camry because of the looks of the redesigned model and because of the legendary Toyota quality and reliability.

As of today, I am a bit disappointed in the build quality of the car.

Disappointed in interior and exterior quality.

Toyota did a great job with design but forgot about quality!

This car needs quality improvement!

The fit and finish in the cabin is not the level of quality I expected.

This car looks great and the build quality is good.

I am so disappointed in the quality.

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.

It’s now apparent that Toyota quality took a nose dive.

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.

Overall a good car, no build quality issues yet.

After owning a 95 Camry, I expected the same quality.

The quality of construction, ride, quietness, and legroom are excellent.

A lot of defects that I still do not understand how my car passed the quality inspection when it was manufactured.

This car offers poor driver’s seat comfort, poor vision, only average ride quality, gas mileage.

JBL radio is low quality cd, fm, and mp3 all sound the same.

It has high quality amazing ride and the fit and finish is great.

However, the quality of this car is not acceptable for Toyota standards.

Initial quality was lacking and it’s only getting worse.

This is our 6th Toyota and we continue to receive the quality we expect.

It’s not worth buying given the quality issues.

Seems the company’s quest to be #1 has caused quality issues.

Interior quality is very poor.

This was the 7th Camry and the last, I feel Toyota quality is slipping big time.

This is not the Toyota quality I was expecting.

Interior exterior quality is very good.

Overall build quality very good.

Replaced speakers with Sony speakers, sound quality improved.

The ride, comfort, and drive is as expected, however, the quality
and reputation of yore are completely gone for the flagship Camry.

It’s not a terrible car by any means, but the quality since they started building them in America has really slipped.

Horrible quality of interior.

Some have mentioned disappointing build quality.

As compared to my wife’s 2004 Highlander, my new Camry does not exhibit the same build quality.

While I applaud the new design, Toyota seems to be slipping in quality.

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.

The ride, the fit and the build quality are what I was expecting after owning Toyotas in the past.

This 2007 is the epitome of the Toyota’s quality.

I also am not impressed with the quality.

The sound quality is excellent and answering or dialing a call couldn’t be easier.

Solid, high quality, comfortable and quiet.

Depends on gas quality & wind conditions.

The fit and finish quality is poor.

Toyota’s quality is slipping.

I paid for quality & all I’ve gotten thus far is NOT quality.

I drive quality cars and I can attest to the fact this car rides as well as some cars costing considerably more.

It is a pleasure to drive and it has Toyota quality written all over it.

Great performance, great gas mileage, superior quality, I always thought of a Camry as just a practical family sedan.

Quality of assembly is outstanding.

Toyota has this supposed impecable quality.

So far the quality appears to be strong, as expected.

High quality inside outside finish.

The quality of the leather seats appears to be very good.

My third Camry and by far the worst, the paint is of poor quality.

Some quality issues with fit and finish.

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.

Front seats are very uncomfortable.

No memory seats, no trip computer, can only display outside temp with trip odometer.

needs power seats on the passenger side.
I haven’t had any back pain from the seats, maybe these people exceed the seat weight limit?

There is a great deal of road noise in the cabin and the seats are very low quality.

Power seats are not fully adjustable.

Front seats are too narrow and not deep enough.

The seats are extremely uncomfortable.

I previously owned a 98 Avalon, and found the seats more comfortable than the Honda.

The seats in the Honda are more firm.

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.

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!

Although it is fun to drive and quality seems ok, the leather seats are very uncomfortable, especially on a long drive.

The seats are decent, the interior design is excellent IMO as well as the exterior design, and thus far it has been extremely reliable.

In fact, I love the car just wish Honda wouldn’t have made such horrible seats.

Body wasn’t used to seats like if you bought a new mattress.

The interior quality is OK, my 1999 Accord EX had a better comfort level on the seats.

I just purchased an Accord Sedan with leather seats.

Only needs to add drivers seat memory, 2 tone perforated leather, xenons, rear seat interior illumination mounted under front seats, and better tilt.

I can also fit three car seats in the back which was the reason I was able to go back the the Honda family.

The seats are very comfortable & supportive.

I test drove an EX, L and felt the seats were too firm plus, the EX, L seemed too slow.

This Accord has more road noise than I like and the seats tend to be hard, unlike my other Accords.

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.

The seats are comfortable, and there is ample leg room in the front and rear.

Most uncomfortable seats in any vehicle I have ever owned.

Only 2 things could make it better memory seats and a smoother shifting transmission.

Seats are firm but not uncomfortable, very BMW like.

Advise anyone considering the L to drive one for awhile if you can, some cannot stand the seats.
The seat cover was coming out in between the seats.
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.
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.
Seats are very comfortable and ride is very smooth!
It’s a black beauty with comfy leather seats.
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.
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.
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.
Great leg room in the back and the seats a very supportive.
Door closure is solid, leather seats are very comfortable.
Ride is very good, but seats are just a little firm.
Seats are not very comfortable and not happy with the heated seats.
The seats are very comfortable and I love the cloth.
Seats are little on the hard side.
The black leather seats feel a bit hot on the back in the warm weather but otherwise no complaints about the interior.
Steering nice and tight, seats a little stiff but comfortable.
We wanted three things, heated seats and mirrors and an easy to get out of back seat for some aging friends.
Ride is superior, comfortable seats, radio excellent.
5 Seats= Like sitting on a church pew.
Leather seats are the only thing of good quality.
Problems with steering wheel, windows & seals, seats.
Smooth responsive acceleration, top of the line high quality supple comfy leather seats.
Also, amazing leg space in front AND back seats, the Accord could almost be considered a full size sedan.
5L V6 scoots sporty handling and acceleration good sporty leather seats highway gas mileage appearance package worth having no dealer service yet Negatives:
First off the new body style is very appealing and the new seats are more forgiving for larger men.
The heated seats for me and my passenger are a plus for the cold weather.

hard seats, hard ride, more road noise than expected, disappointing gas mileage.

The seats are supportive and the materials are great.

You get a V, 6, heated leather seats, XM, 18 rims.

Cloth front seats big & comfortable.

After slowing down, transmission has to be kicked to speed up.

I wonder if the people who have problems with rattles and transmission were built in the US.

The transmission, I don’t know what to tell you, but good luck if you don’t learn from my mistake.

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.

I’ve had the same transmission problems hesitation issues as everyone else.

I immediately starting noticing transmission surge during 2nd and 3rd gear during first few minutes of driving.

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 doesn’t move & scares me and when it does move it revs even after take your foot from the gas.

The transmission doesn’t shift correctly, and it has almost caused me to get into an accident twice.

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.

Unlike the common concerns with the transmission, all of my concerns problems are with everything other than the drivetrain.

decent power for a 4 cylinder, but a dangerous hesitating transmission that toyota does not seem to want acknowledge or fix.

My Camry has been in the shop four times for the transmission problem and still has not been fixed.

First thing that come to me off the top of my head is the transmission.

The transmission is the worst ever for camry.

However, there are too many problems with the transmission.

I have the 4 cylinder with manual transmission.

I’ve had no significant transmission problems.

Transmission is terrible,, acceleration lag is a safety issue.

Transmission also can’t decide what gear it wants to be in.
Transmission was replaced by Toyota in the first year.

The transmission feels terrible when it shifts.

The transmission is crap, and erratically shifts despite modest acceleration and conservative driving habits.

The transmission shifts smooth at all speeds.

No sign of the transmission problem people have complained about, but I’m not expecting a Porsche.

No rattles or transmission problems.

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.

Had 2 TSBs done to recalibrate engine, transmission.

The engine and transmission works flawlessly when a particular brand of fuel is used and I am absolutely sure I am correct.

I have the transmission problem.

No transmission problems as reported by so many others.

The engine transmission was a Jekyll Hyde affair.

Here are the transmission problems I’ve experienced:

Transmission is confused and CONTINUALLY shifts at speeds of 28 to 35, 38 to 42, and 45 to 51 MPH.

At this rate, the Transmission will go out @ 37,000 miles right after my Warranty expires!

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!

Toyota now has a fix for the accelerator hesitation and transmission problem!

EG7031 recalibrate ECM engine and transmission 9159 Bulletin # EG036, 07.

I’m not sure what everyone talks about with hesitation transmission not enough power?

The transmission cant make up its mind it hesitates to shift.

Transmission sticks in fourth gear and rpm surge while using the cruise control.

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.

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.

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.

While driving on a straight and level road at about 40 mph the transmission is changing gears.

Loved the car but two transmissions failed within 19000 miles before I got rid of the car.
The transmission design has major problems and so did the replacement.

My dealer told me the new transmissions were on back order and couldn’t even give me an ETA.

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.

My transmission works perfectly fine, is fun to shift but does better on its own.

below the advertised numbers, and a jerky, balky, surging transmission that is difficult to use.

Terrible transmission that doesn’t shift right.

the significant transmission hesitations are unacceptable and possibly unsafe, and the 4 cyl engine provides inadequate power when challenged.

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.

After one week, I found a rusted conjunction block, which mounts the transmission.

BTW, this is an auto transmission.

I hate the transmission as it always hesitates to downshift when the power and speed is needed.

No problems with the transmission at all.

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.

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.

No transmission flares, hesitations, rattles or any other problems.

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.

The gas pedal & transmission are out of sync.

At lower speeds when you try to give it gas an intermittent delay occurs between the gas pedal & transmission.

Acceleration or transmission shifting:

Quiet and refined ride, 4 cyl has sufficient power for everyday driving, and a smooth transmission that shifts well.

Transmission not nearly as smooth as previous 4 speed.

The transmission does occasionally get confused and takes a while to select the right ratio, but this does not occur frequently.

The transmission is weak, you need to think twice before jumping
into traffic .

Obviously since I got the manual transmission I haven’t had any problems with acceleration or anything like that .

Transmission has a very strange hesitation when shifting .

Performance stinks due to transmission, always looking for another gear, constantly jerking, dash lights always dimming, lower grill always slipping out .

When we returned home, I took the car to a transmission specialist and found out that the transmission is slipping .

Rattles, squeaking, and transmission troubles started shortly after .

I wanted a larger car that was comfortable and the redesign of the Accord making it bigger made the difference .

The car is VERY comfortable and the air conditioning is perfect for the heat here in Arizona .

It’s VERY bothersome when the transmission down shifts the second one brakes when going down a mountain .

The speed control as well is balky in that the slightest uphill grade causes the transmission to down shift .

The accelerating is great, the transmission is smooth, it handles well and breaking is excellent .

I loved my ’05 Camry 4 cyl automatic transmission LE, but I hate my ’07 Camry 4 cyl automatic transmission LE .

Many people have mentioned a hesitation in the transmission I haven’t seen it .

Ash leather interior with light yellow fake wood trim is just ok design .

After researching on the internet I found that the computer for the transmission needed reprogrammed .

No transmission problems, reacts instantaneously .

However, the transmission is a little confused at times during downshifting .

This is my second Camry and I like it, especially the art decoish design and simplicity of interior controls .

I have had issues with the new 6 speed transmission, there is a shift flare between 3rd and 4th gear with my car .

Toyota is aware of the problem and they are actually replacing my transmission since they cannot figure out what the cause is .

Hopefully once I get a new transmission, it will be OK .

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 .

Dealer recalibrated ECU, engine and transmission .

Test drove identical camry at a different dealer transmission reacts same way .

Transmission slips, especially when the car is cold .

Transmission replacement did not resolve the problem .
Transmission is exceptionally smooth other than the first few shifts on a cold winter morning.

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.

The six speed auto transmission is very smooth.

After driving this car for a month it is very obvious to me that there is a design flaw in the transmission.

The transmission constantly shifts back and forth between gears.

The transmission is just terrible.

Transmission is a little different than previous Camrys but MPG and better accel.

It has plenty of power for my needs and I have noticed no transmission problems at all.

Like everyone else, I have the problem with the transmission.

I have had non, stop transmission problems, terrible sunroof noises, very uncharacteristic squeaks and rattles from everywhere in the dash, and unacceptable paint issues.

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.

The transmission leaves a lot to be desired.

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.

Toyota made a real goof on the engine and transmission!

Transmission shifts up and down at highway speeds, which is annoying.

However, the transmission is sloppy.

It’s automatic transmission is jerky and sometimes hesitant about changing gears.

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.

Also, the shifting in the transmission is herky jerky.

the auto transmission is very poorly designed and Toyota hasn’t decided what to do.

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.

After purchasing my 2007 Camry, which was a hassle because the salesman was pushy, I started having trouble with the transmission slipping!

The transmission hesitates, also downshifts, hunting between gears, then lurches.
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.

The only negative is the shifting of the transmission from 40 to 40. The transmission is the nightmare many have already talked about.

Perhaps the most annoying thing to me, the transmission kicks up and down on shallow declines, never had this in any automatic before.

If you care about a smooth transmission run don’t walk away from the 4cyl automatic 2007 camry.

This Accord model has a great balance of features that blends attractive styling, driveability, build quality, economy, and comfort with all the loaded options that I will enjoy over several years and 100000.

The car is roomy inside, comfortable, handles and performs great and is fun to drive.

Cloth front seats big & comfortable.

Seats are stiff but once adjusted seem to become more comfortable.

Traded in my Oddysey for better gas mileage and more comfort.

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.

Comfort is my only real complaint.

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.

On the inside, it was for the most part comfortable and luxurious.

The only hiccup I can report is that I think that the seats in our 2008 Odyssey are a bit more comfortable.

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.

The 2008 Honda Accord EX, L V6 is an ideal combination of comfort, economy, and pleasure.

No, the Honda does not have the anti, sway of those vehicles in high, cornering speeds, but it is more comfortable.

Was looking for something fun, fast, comfortable and practical and got it all with this car.

There is an amazing comfort level with this car.

Comfort based on the quality and attention to detail Honda efficiently packs into this newly reclassified full size car.

The interior is comfortable, neat and you can find everything within reach.

The heated leather seat is very comfortable and audio system is rocking.
Although it’s a lower trim level, it has high quality interior trim, very comfortable seats, and a very smooth, quiet ride.

I love the interior layout and comfort. 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 you will get soaked. Very roomy and comfortable even with 5 adults.

At 6’3 I can sit comfortably in the driver’s seat and have an unobstructed view out the windows. I commute a lot, so interior is important to me, and its leather does not seem cheap and comfort is top notch. Gliding can best define the comfort and quietness of the ride inside.

With the leather seats, comfort is close to EX, L’s at a best buy price. I traded in a 2007 Hyundai Azera Limited that depreciated too fast for my comfort zone.

Leather seats are very comfortable. Interior is very comfortable with ergonomic design in mind. Front seats much more comfortable. Comfortable, good in snow, easy to drive.

The driver side seat is not comfortable. This car is very comfortable car to drive. Driver seat could be more comfortable however, but I love everything about it.

I find the interior comfortable for short and long trips. My wife does say the vehicle is not as comfortable for long trips as other cars we’ve owned.

Comfortable ride no thanks to the comfort of the driver’s seat! Very comfortable drive, holds the road very nicely and a blast to drive.

The Accord is so large, comforting, and easy to understand radio system.

I was slightly concerned about all the reviews with the seats being uncomfortable. Leather seats were comfortable. Leather interior very comfortable.

My conclusion after doing a ton of research regarding safety, reliability, comfort and gas mileage: the Hyundai Sonata is thousands of dollars cheaper and matches the Camry in all respects except comfort.

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.

While the ’03 was roomy and comfortable, the steering and handling were very vague.

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

Interior is very comfortable with ergonomic design in mind.
Purchased Accord Feb 2008 V6 EX Cloth interior.
I find the interior comfortable for short and long trips.
Tonight I find that my headlights, brake lights, and interior lights all flicker every 20 seconds when the air conditioner is running.

Interior is very comfortable with ergonomic design in mind.
Purchased Accord Feb 2008 V6 EX Cloth interior.
I find the interior comfortable for short and long trips.
Tonight I find that my headlights, brake lights, and interior lights all flicker every 20 seconds when the air conditioner is running.

Interior is good but has quite a few rattles.

At highway speeds, the interior remains quiet, with little to no wind or road noise.

However I have few complaints about the interior.

IMHO, the exterior and performance are way better than other trims, though you can’t compare interior of SE with XLE.

Interior is extremely quiet on the highway.

Love the looks, power, roomy interior, good mileage at 32 hwy and 25 city.

Interior still has too much hard plastic, especially the steering wheel, which has a raised crease hitting on the fingers as a constant reminder.

It has nice luxury interior, but it also has nice pick up speed and is very roomy.

Excellent interior build quality.
The new interior design is okay to me, the blue, background center console is a little bit awkward, too bright at night.

Leather interior very comfortable.

Nice looking interior but seats are very hard and are not comfortable for long trips.

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.

My Barcelona red metallic exterior and dark charcoal interior are a perfect combination.

Top notch rating on interior comfort.

All around this car is amazing, its sleek exterior and futuristic interior is sure to turn some heads.

Second, the interior designer should be fired.

It is surprising how spacious the interior is on a long trip.

The plastic interior looks and feels cheap.
The interior is okay and I have not had any rattles or squeaks.
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.

Mileage looks like it will be a little less than the older V6 Hondas.

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.

Negatives:

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't?

VCM works out nice for better mileage.

And great gas mileage averaging 28.

Very disappointed in mileage.

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 disappointing getting 5 mpg less then 06 Accord.

My only really complaint is the gas mileage is not as good as advertised.

Mileage is decent around 24, 27.

Traded in my Oddysey for better gas mileage and more comfort.

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.

Gas mileage will surely improve, hopefully.

The trade, off is a bit lower mileage but still better than most out there.

Having had to give up my 99 Accord due to very high mileage 170K.

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.

Mileage so far is the big disappointment, low 20’s, old Accord was never below 27mpg.

Telling me how good the gas mileage is not true.

Gas mileage is great for a vehicle with this type of performance.

The car has ample power, but the gas mileage has been disappointing.

The car is as big and roomy inside as my old Acura RL, handles better and gets better gas mileage.

It’s fun to drive, and gets great gas mileage.

Handles great, good mileage, and wonderful ride.

The Accord was quiet, was easy to drive, seemed to be the right size, and would provide decent mileage.

It was the combination I was looking for, great look, good value, decent gas mileage, and Honda’s resale value.

The windshield wash barely hits the windshield but I am mostly disappointed in the gas mileage.
I do not know what these people are talking about saying it gets bad gas mileage!

Car rides great, good fuel mileage.

Gas mileage is not as advertised, 25 mpg at most.

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.

Fuel mileage is disappointing 15 18 city 22 26 hwy.

Gas mileage not quite as good as advertised.

Gas mileage is above average.

Great power, great ride, and pretty good fuel mileage.

Gas mileage is at it’s highest 24 mpg usually 22 mpg hwy.

Little 4cyl 5 spd LX and it got awesome gas mileage.

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.

I admire engine performance and comfort while driving at least 30 mile a day to job.

I have owned 4 honda’s and have come to rely on the fantastic quality of performance and lack of maintenance issues.

The car is superb, performance, styling, quality, engineering, fit and finish, the whole banana!

The performance is incredible!

Gas mileage is great for a vehicle with this type of performance.

I could not be happier with the performance and ride of this car.

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.

Honda has outdone itself on styling and performance.

Its ride, comfort and overall performance is an absolute joy.

Excellent interior build quality.

Was sold by the reputation for quality, reliability, and the 2007 redesign.

Vehicle ride is extremely smooth, compliant and quiet, very close to Lexus quality for thousands of dollars less.

The new 2007 Camry should have the higher quality than 1997 Camry, but not in my case.

I just feel the car is quality throughout.

The 07 Camry is a high quality car at a very affordable price.

However, the quality is absolutely terrible for a Toyota.

I will keep this car, but I hope Toyota improves their quality to their older standards of the mid 90s.

My transmission works seamlessly and there are no quality issues whatsoever.

I was driving 91 Camry for long time and it’s quality deeply impressed me.

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.

Seats are stiff but once adjusted seem to become more comfortable.

The seats are very firm, but getting used to this.

The seats in my 2008 which is just like a 2009 are considerably less than I'm used to from Honda.

The only hiccup I can report is that I think that the seats in our 2008 Odyssey are a bit more comfortable.

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.

I have two herniated disks and the seats of the Honda have alleviated the pain in my legs and back when I drive.

Although it’s a lower trim level, it has high quality interior trim very comfortable seats and and very smooth, quiet ride.

Decent accel, huge back seat for my kids baby seats large friends.

we don’t need moonroof, heated seats side mirrors we live in S.

With the leather seats, comfort is close to EX, L’s at a best buy price.

Seats are a bit too firm for me.

Leather seats are very comfortable.

The inside and outside pads should ALWAYS wear evenly Always had stiff ride and seats.

I have a bad lower back, and the lumbar support on the seats is a life saver!

Front seats much more comfortable.

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.

We are both tall, 5’11 and 6’2 and have no problems with the seats.

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.

Seats are too firm and leather is quite hard in character and feel.

I was slightly concerned about all the reviews with the seats being uncomfortable.

I love the seats, they are supportive.

LE 2007, 4cy, minor transmission hesitations as I see many other are experencing.

Transmission does not know sometimes what it is doing when it?

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
Due to lack, of, power or transmission problem, car down, shifts revs to 3000
Transmission is smooth and the 2.
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.
The transmission and cruise control is a joke.
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.
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.
The transmission is not the smoothest.
268 HP V6 with 6 speed auto transmission is very responsive and smooth.
The transmission is seamless and, with six forward gears, the engine is virtually never strained in ordinary driving.
8 Transmission hunts for gears 9 Driver side head liner molding buzzes.
11 Transmission unexpectedly deaccelerates during a slow down.
However I have noticed, like others, that the new transmission is not that smooth, especially when accelerating from a stop.
The 5 speed transmission shifts like one would with a manual.
The transmission, or more specifically, the power transfer is scary.
The reprogramming of the transmission shifting seemed to help for awhile, but it’s reverted back.
The transmission computer is a major issue.
Dealers do not handle the transmission matters well as I’ve had no luck in clearing up the inadequacies.
The transmission is jerky and the gas mileage is terrible.
It has major transmission issues, which I have had fixed twice.
My transmission works seamlessly and there are no quality issues whatsoever.
The transmission is driving me crazy.
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.
Transmission was very rough, dealership reprogrammed, it’s ok now.
The new transmission shifts too frequently to truly optimize gas consumption.
The transmission is the absolute WORST, it is very dangerous and can cause an accident.
They have finally fixed my transmission.
Only problem has been the proprietary transmission glitch everyone talks about.
I have 4 cyl with manual transmission, lack of power but great fuel economy.
Transmission big issue and also rattles more than the 2001 Avalon that had 175K miles.
APPENDIX C. SOURCE CODE IN PYTHON FOR CRF IMPLEMENTATION

# -*- coding: utf-8 -*-

'''
Created on Wed Aug 29 17:18:19 2018

@author: Yue Ming
'''

""
CRF Implementation in Python
""

####################################
# Define Functions #
####################################

#####
# Create Corpus #
#####

from collections import defaultdict

def read_corps(corpsfile):
    corps = []
    words = ['<S>']  # the words list start with "<S>", as initial state and end state
    tags = [0]
    tagids = defaultdict(lambda: len(tagids))  # create a collection for tags
tagids[ '<S>' ] = 0
for texts in corpsfile:
    for word in texts:
        words.append(word[0].lower()) # if not a number, transform to lower case
tags.append(tagids[word[1]])
words.append( '<S>' ) # end a words list for the current sentence with "<S>" as end state
tags.append(0)
corps.append((words, tags))
# reset lists for new sentence
words = [ '<S>' ]
tags = [ 0 ]
return corps, tagids

class Logspace:
def __init__(self):
    self.LOGZERO = np.nan
def eexp(self, x): # take exp value
    if np.isnan(x):
        return 0
    else:
        return np.exp(x)
def eln(self, x): # take natural log
    if x == 0:
        return self.LOGZERO # if 0, return nan
    elif x > 0:
        return np.log(x)
    else:
        print ('Error! Negative input.‘)
        return np.nan

def elnsum(self, elnx, elny):
    if np.isnan(elnx):
        return elny
    elif np.isnan(elny):
        return elnx
    elif elnx > elny:
        return elnx + self.eln(1+np.exp(elny-elnx)) # log(x) + log(1 + exp(log(y)-log(x))) = log(x+y)
    else:
        return elny + self.eln(1+np.exp(elnx-elny)) # log(y) + log(1 + exp(log(x)-log(y))) = log(x+y)

def elnproduct(self, elnx, elny): # input log value
    if np.isnan(elnx) or np.isnan(elny):
        return self.LOGZERO
    else:
        return elnx + elny # log(x*y) = log(x) + log(y)

def elnmatprod(self, elnx, elny): # log matrix multiplication
xsize = np.size(np.shape(elnx))
ysize = np.size(np.shape(elny))

if xsize == 1 and ysize == 1:
    r = self.LOGZERO
    for i in range(np.shape(elnx)[0]):
        r = self.elnsum(r, self.elnproduct(elnx[i], elny[i]))

    return r
elif xsize == 1 and not ysize == 1:
    n = np.shape(elny)[1]
    r = np.zeros(n)
    for i in range(n):
        r[i] = self.elnmatprod(elnx, elny[:, i])  # x times i th col of y

    return r
elif not xsize == 1 and ysize == 1:
    n = np.shape(elnx)[0]
    r = np.zeros(n)
    for i in range(n):
        r[i] = self.elnmatprod(elnx[i, :], elny)  # ith row of x times y

    return r
else:
    m, n = np.shape(elnx)
p = np.shape(elny)[1]
r = np.zeros((m, p))
    for i in range(m):
        for j in range(p):
r[i][j] = self.elnmatprod(elnx[i, :], elny[:, j])  # ith row of x times jth col of y

return r

def eexpmat(self, elny):  # take matrix exp, input log value
    expy = np.copy(elny)
    if np.size(np.shape(elny)) == 1:
        for i in range(np.shape(elny)[0]):
            expy[i] = self.eexp(expy[i])
    else:
        for i in range(np.shape(elny)[0]):
            for j in range(np.shape(elny)[1]):
                expy[i][j] = self.eexp(expy[i][j])
    return expy

def elnmat(self, x):  # take matrix log, input original value
    elnx = np.copy(x)
    if np.size(np.shape(x)) == 1:
        for i in range(np.shape(x)[0]):
            elnx[i] = self.eln(x[i])
    else:
        for i in range(np.shape(x)[0]):
            for j in range(np.shape(x)[1]):
                elnx[i, j] = self.eln(x[i, j])
    return elnx

logspace = Logspace()
def getfeatureTS(corps):
    featuresets = set()  # set of features
    featureT = []
    featureS = []
    for corp in corps:
        for i in range(np.shape(corp[0])[0]):
            if corp[0][i] == '<S>':
                continue
            if ('S', corp[0][i], corp[1][i]) not in featuresets:
                featuresets.add(('S', corp[0][i], corp[1][i]))
                featureS.append(('S', corp[0][i], corp[1][i]))
            if corp[0][i-1] != '<S>':
                if ('T', corp[1][i-1], corp[1][i]) not in featuresets:  # combine duplicated transition combination to calculate prior probability
                    featuresets.add(('T', corp[1][i-1], corp[1][i]))
                    featureT.append(('T', corp[1][i-1], corp[1][i]))
    featureTS = featureT + featureS
    word_to_tagid = word_tagid_from_featureS(featureS)
    return featureTS, word_to_tagid, featureT, featureS
# Calculate prior expectation for transition and emission#

###########################################################

def getpriorfeatureE(corps, featureTS):
    N = np.shape(corps)[0]  # size of training set
    K = np.shape(featureTS)[0]  # number of features
    priorfeatureE = np.zeros(K)  # return a new array of given
    shape and type, filled with zeros
    for corp in corps:  # corp is tuple in corps, for each
        sentence tuple in corps
            for i in range(np.shape(corp[0])[0]):
                if corp[0][i] == '<S>':
                    continue
                try:
                    idex = featureTS.index(('S', corp[0][i], corp[1][
                        i]))  # get index of a word with its tagid
                    priorfeatureE[idex] += 1.0
                except:
                    pass
                try:
                    idex = featureTS.index(('T', corp[1][i-1], corp
                        [1][i]))  # get index of transition combination
                    priorfeatureE[idex] += 1.0  # calculate the number
                    of occurrence of a transition combination
                except:
                    pass
    priorfeatureE /=N  # divided by the number of sentences
    return priorfeatureE
# Create word-tagid pair list#

```python
def word_tagid_from_features(featureS):  # list of words with corresponding features that appeared in training data
    word_to_tagid = {}
    for feature in featureS:
        word = feature[1]
        state = feature[2]
        if word in word_to_tagid:
            word_to_tagid[word].append(state)
        else:
            word_to_tagid[word] = [state]
    return word_to_tagid
```

# Train feature weights#

```python
def getpostfeatureE(weights, corps, featureTS, word_to_tagid):  # see wallach04conditional for details: CRF Probability as Matrix Computations
    K = np.shape(featureTS)[0]  # number of features
    postfeatureE = np.zeros(K)  # initialize posterior probability of features
    N = np.shape(corps)[0]  # sample size or number of sentences
```
for corpidx in range(N):
    corp = corps[corpidx][0][1:-1] # each original sentence without <S>
    lencorp = np.size(corp) # number of words in the sentence
    Mlist = {}
    Mlist['mat'] = ['']*(lencorp+1)
    Mlist['dim'] = [word_to_tagid[corp[i]] for i in range(lencorp)]
    Mlist['len'] = [np.size(word_to_tagid[corp[i]]) for i in range(lencorp)]
    for i in range(lencorp+1):
        if i == 0: # first word in the sentence doesn’t have transition, so only calculate the word’s emission weight
            d = Mlist['len'][0]
            Mlist['mat'][i] = np.zeros((1, d))
            for j in range(d):
                Mlist['mat'][i][0, j] = weights[featureTS.index(('S', corp[0], word_to_tagid[corp[0]][j]))]
            continue
        if i == lencorp: # last entry is a seudo value, assign a matrix with a col array popped with 0
            Mlist['mat'][i] = np.zeros((Mlist['len'][-1], 1))
            continue
        Mlist['mat'][i] = np.zeros((Mlist['len'][i-1], Mlist['len'][i])) # previous word, current word
        for d1 in range(Mlist['len'][i-1]):
            for d2 in range(Mlist['len'][i]):
id1 = word_to_tagid[corp[i-1]][d1]  # tag of the previous word
id2 = word_to_tagid[corp[i]][d2]  # tag of the current word

try:
    Sweight = weights[featureTS.index(('S', corp[i], id2))]
except:
    Sweight = 0

try:
    Tweight = weights[featureTS.index(('T', id1, id2))]
except:
    Tweight = 0

Mlist['mat'][i][d1, d2] = Sweight + Tweight

z = np.array([0])  # Partition function, summation of all possible combinations
for i in range(lencorp+1):  # for each word
    z = logspace.elnmatprod(z, Mlist['mat'][i])
Alphalist = ['']*(lencorp+2)
Betalist = ['']*(lencorp+2)
Alphalist[0] = np.zeros((1, 1))  # forward array, (row, col), initial seudo value, 1x1 matrix of 0
Betalist[-1] = np.zeros((Mlist['len'][-1], 1))  # backward array (row, col), initial value of last seudo value of 0
for i in range(1, lencorp+2):  # forward array, single row matrix
    Alphalist[i] = logspace.elnmatprod(Alphalist[i-1],
for i in range(lencorp, -1, -1): # backward array, single column matrix;
    Betalist[i] = logspace.elnmatprod(Mlist['mat'][i],
    Betalist[i+1])
for i in range(1, lencorp+1): # for each word
    d1, d2 = np.shape(Mlist['mat'][i-1]) # row - tags of previous word, col - tags of current word
    for di in range(d1):
        for dj in range(d2):
            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
            if i == 1: # when i = 1, first word, no transition, only emission; when i = lencorp+1 last element <S>, no transition nor emission
                try:
                    Sidex = featureTS.index(('S', corp[i -1], Mlist['dim'][i-1][dj]))
                    postfeatureE[Sidex] += plocal
                except:
                    pass
            else:
                try:
Sidex = featureTS.index(('S', corp[i-1], Mlist['dim'][i-1][dj])) # emission
postfeatureE[Sidex] += plocal
except:
    pass
try:
    Tidex = featureTS.index(('T', Mlist['dim'][i-2][di], Mlist['dim'][i-1][dj])) # transition
    postfeatureE[Tidex] += plocal
except: # if no transition, ignore
    pass
postfeatureE /= N
return postfeatureE

def getliknegvalue(weights, corps, featureTS, word_to_tagid): # minimize negative loglikelihood function
    K = np.shape(featureTS)[0] # number of features
    N = np.shape(corps)[0] # number of sentences
    liknegvalue = 0
    for corpidx in range(N):
        corp = corps[corpidx][0][1:-1] # words without <S>
        tag = corps[corpidx][1][1:-1] # tags without tags for <S>
lencorp = np.size(corp)  # number of words in current sentence

Mlist = {}
Mlist['mat'] = ['']*(lencorp+1)
Mlist['dim'] = [word_to_tagid[corp[i]] for i in range(lencorp)]
Mlist['len'] = [np.size(word_to_tagid[corp[i]]) for i in range(lencorp)]

for i in range(lencorp+1):
    if i == 0:  # if start, only emission
        d = Mlist['len'][0]
        Mlist['mat'][i] = np.zeros((1, d))
        for j in range(d):
            Mlist['mat'][i][0, j] = weights[featureTS.index(('S', corp[0], word_to_tagid[corp[0]][j]))]
        continue
    if i == lencorp:
        # if last, array of 0s
        Mlist['mat'][i] = np.zeros((Mlist['len'][-1], 1))
        continue
        Mlist['mat'][i] = np.zeros((Mlist['len'][i-1], Mlist['len'][i]))
    for d1 in range(Mlist['len'][i-1]):
        for d2 in range(Mlist['len'][i]):
            id1 = word_to_tagid[corp[i-1]][d1]
            id2 = word_to_tagid[corp[i]][d2]
            try:
                Sweight = weights[featureTS.index(('S',
except:
    Sweight = 0
try:
    Tweight = weights[featureTS.index(('T', id1, id2))]
except:
    Tweight = 0
Mlist['mat'][i][d1, d2] = Sweight + Tweight

numerator = 0  # sum of all observed features
denominator = np.array([[0]])  # the Z value
for i in range(lencorp+1):  # for each word
    denominator = logspace.elnmatprod(denominator, Mlist['mat'][i])
    if i == 0:  # beginning word
        numerator = logspace.elnproduct(numerator, Mlist['mat'][i][0, Mlist['dim'][i].index(tag[i])])
    elif i < lencorp:  # elsewhere in the sentence, sum all weights of observed features
        numerator = logspace.elnproduct(numerator, Mlist['mat'][i][Mlist['dim'][i-1].index(tag[i-1]),
                                                                     Mlist['dim'][i].index(tag[i])])
liknegvalue += (denominator - numerator)/N  # negative loglikelihood function
return liknegvalue[0,0]  # a single value

# Calculate gradient
def getgradients(priorfeatureE, weights, corps, featureTS,
word_to_tagid):
    postfeatureE = getpostfeatureE(weights, corps, featureTS, 
                   word_to_tagid)
    return postfeatureE - priorfeatureE

#############################################################################
# Two-loop recursion  
#############################################################################

def twoloop(s, y, rho, gk): # compute search direction in L-BFGS, 
                       # approximate inverse of hessian matrix
    n = len(s)

    if np.shape(s)[0] >= 1:
        h0 = 1.0*np.dot(s[-1],y[-1])/np.dot(y[-1],y[-1]) # https://en.wikipedia.org/wiki/Limited-memory_BFGS
    else:
        h0 = 1

    a = np.empty((n,))

    q = gk.copy() # q is the gradients
    for i in range(n - 1, -1, -1): # from n-1 to 0 decreasing by 1
        a[i] = rho[i] * np.dot(s[i], q) # rho is defined as 1/(transpose(yk)*sk)
        q -= a[i] * y[i]

    z = h0*q

89
for i in range(n):
    b = rho[i] * np.dot(y[i], z)
    z += s[i] * (a[i] - b)
return z  # The value of zk is the approximation for the
direction of steepest ascent

#############################################################
# L-BFGS Optimization #
#############################################################
def lbfgs(fun, #= getliknegvalue, neg-likelihood function
gfun, #= getgradients, first-derivative
x0, #= weights, initial weights
corps, #= corps,
featureTS, #= featureTS,
word_to_tagid, #= word_to_tagid,
priorfeatureE, #= priorfeatureE,
m, # number of previous steps to be stored
maxk):
    rou = 0.55  # initial step-size
    sigma = 0.4
    epsilon = 1e-5
    k = 0
    n = np.shape(x0)[0]  # dimension of weights
    s, y, rho = [], [], []
    while k < maxk :  # max number of iterations
gk = gfun(priorfeatureE, x0, corps, featureTS, word_to_tagid)  # getgradients(priorfeatureE, weights, corps, featureTS, word_to_tagid)

if np.linalg.norm(gk) < epsilon:  # Euclidean norm of gk
    break

dk = -1.0*twooloop(s, y, rho, gk)  # search directions, originally defined as -Hk*gk, but approximated by zk from twooloop recursion

m0=0;

mk=0

funcvalue = fun(x0, corps, featureTS, word_to_tagid)  # getliknegvalue(weights, corps, featureTS, word_to_tagid)

while m0 < 20:  # Armijo Rule to control step size
    if fun(x0+rou**m0*dk, corps, featureTS, word_to_tagid) < funcvalue+sigma*rou**m0*np.dot(gk, dk):
        mk = m0
        break

    m0 += 1

x = x0 + rou**mk*dk  # http://www-personal.umich.edu/~mepelman/teaching/NLP/Handouts/NLPnotes12_5.pdf

sk = x - x0

yk = gfun(priorfeatureE, x, corps, featureTS, word_to_tagid) - gk

if np.dot(sk,yk) > 0:  # add new value in array
    rho.append(1.0/np.dot(sk, yk))
    s.append(sk)
y.append(yk)

if np.shape(rho)[0] > m:  # delete old value in array
    rho.pop(0)
    s.pop(0)
    y.pop(0)

k += 1
x0 = x
print(‘Iteration %d, liknegvalue %f’%(k,funcvalue))

return x0, fun(x0, corps, featureTS, word_to_tagid)

##################################
# Viterbi backtracking algorithm #
##################################

def viterbi_backtracking(corps):
    K = np.shape(featureTS)[0]
    N = np.shape(corps)[0]
    path_collection =[]
    for corpidx in range(N):
        corp = corps[corpidx][0][1:-1]
        lencorp = np.size(corp)
        Mlist2 = {}
        Mlist2[‘mat’] = [‘’]*(lencorp)
        Mlist2[‘dim’] = [word_to_tagid[corp[i]] for i in range(lencorp)]
        Mlist2[‘len’] = [np.size(word_to_tagid[corp[i]]) for i in range(lencorp)]
for i in range(lencorp):
    if i == 0:
        d = Mlist2['len'][0]
        Mlist2['mat'][i] = np.zeros((1, d))
        for j in range(d):
            Mlist2['mat'][i][0, j] = post_weights[
                featureTS.index(('S', corp[0],
                                word_to_tagid[corp[0]][j]))]
            continue
        Mlist2['mat'][i] = np.zeros((Mlist2['len'][i-1],
                                     Mlist2['len'][i]))  # previous word, current word
        for d1 in range(Mlist2['len'][i-1]):
            for d2 in range(Mlist2['len'][i]):
                id1 = word_to_tagid[corp[i-1]][d1]  # tag of
                                              # the previous word
                id2 = word_to_tagid[corp[i]][d2]  # tag of the
                                              # current word
                try:
                    Sweight = post_weights[featureTS.index((
                        'S', corp[i], id2))]
                except:
                    Sweight = 0
                try:
                    Tweight = post_weights[featureTS.index((
                        'T', id1, id2))]
                except:
                    Tweight = 0
                Mlist2['mat'][i][d1, d2] = Sweight + Tweight
        path = []  # store path
for i in range(lencorp):
    if i == 0:  # beginning word
        score_prev = Mlist2['mat'][i]  # i-1
        continue
    score_current = np.zeros((Mlist2['len'][i-1], Mlist2['len'][i]))
    # score_M will always be a row matrix, it is the column argmax
    for d1 in range(np.size(score_prev)):
        for d2 in range(Mlist2['len'][i]):
            score_current[d1,d2] = score_prev[0,d1] + Mlist2['mat'][i][d1, d2]
    score_prev = np.amax(score_current, axis=0).reshape(1, Mlist2['len'][i])  # update score_pre for next word
    max_index = score_current.argmax(axis=0)
    from_ = []
    to_ = []
    for loc_max in range(np.size(max_index)):
        from_.append(Mlist2['dim'][i-1][max_index[loc_max]])
        to_.append(Mlist2['dim'][i][loc_max])
    path.append(list(zip(from_, to_)))

    # backtracking
    max_to_ = score_prev.argmax(axis=1)[0]  # determine the column of max score
    final_path = []  # store backtracking path
    for pth in range(len(path), -1, -1):
if pth == len(path):
    node_to = path[pth-1][max_to_][1] # ending node
    node_from = path[pth-1][max_to_][0]
    final_path.append(node_to)
    final_path.append(node_from)
    continue

if pth == 0:
    break

node_from = [num for num in path[pth-1] if (node_from in num) == True][0][0] # update node_from

final_path.append(node_from)
final_path.reverse()
path_collection.append(final_path)

return path_collection


#########################
# Print Confusion Matrix#
#########################

def print_cm(cm, labels, hide_zeros=False, hide_diagonal=False, hide_threshold=None):
    '''pretty print for confusion matrixes'''
    columnwidth = max([len(x) for x in labels] + [5]) # 5 is value length
    empty_cell = " " * columnwidth
    # Print header
    print(" " + empty_cell, end=" ")
for label in labels:
    print("%{0}s".format(columnwidth) % label, end=" ")
print()
# Print rows
for i, label1 in enumerate(labels):
    print(" %{0}s".format(columnwidth) % label1, end=" ")
    for j in range(len(labels)):
        cell = "%{0}.1f".format(columnwidth) % cm[i, j]
        if hide_zeroes:
            cell = cell if float(cm[i, j]) != 0 else empty_cell
        if hide_diagonal:
            cell = cell if i != j else empty_cell
        if hide_threshold:
            cell = cell if cm[i, j] > hide_threshold else empty_cell
        print(cell, end=" ")
    print()

def plot_confusion_matrix(cm,
                           target_names,
                           title='Confusion matrix',
                           cmap=None,
                           normalize=True):
given a sklearn confusion matrix (cm), make a nice plot

Citation
---------
    plot_confusion_matrix.html

import matplotlib.pyplot as plt
import numpy as np
import itertools

accuracy = np.trace(cm) / float(np.sum(cm))
misclass = 1 - accuracy

if cmap is None:
    cmap = plt.get_cmap('Blues')
plt.figure(figsize=(12, 10), dpi=300)
plt.imshow(cm, interpolation='nearest', cmap=cmap)
plt.title(title)
plt.colorbar()

if target_names is not None:
    tick_marks = np.arange(len(target_names))
    plt.xticks(tick_marks, target_names, rotation=45)
    plt.yticks(tick_marks, target_names)
if normalize:
    cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
thresh = cm.max() / 1.5 if normalize else cm.max() / 2
for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
    if normalize:
        plt.text(j, i, "{:0.4f}".format(cm[i, j]),
        horizontalalignment="center",
        color="white" if cm[i, j] > thresh else "black")
    else:
        plt.text(j, i, "{:f}".format(cm[i, j]),
        horizontalalignment="center",
        color="white" if cm[i, j] > thresh else "black")
plt.tight_layout()
plt.ylabel('True label')
plt.xlabel('Predicted label
accuracy={:0.4f}; misclass={:0.4f}'.format(accuracy, misclass))
plt.show()

######################
# Extract word index #
######################
def word_index_extractor(word_type, word_path_list):
    word_index = []
    for i in word_path_list:
        word_loc = []
        for word in word_type:
            word_loc.append()
if word not in i:
    continue

    word_loc += ([idx for idx, w in enumerate(i) if w == word])  # extract the index of satisfied word POS
    word_index.append(sorted(word_loc))  # maintain word’s order

    return word_index

from operator import itemgetter

def word_extractor(word_index, tokenized_sentence_list):
    type_word = []
    for i in range(len(tokenized_sentence_list)):
        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
            actual_word = []
            type_word.append(actual_word)  # append empty element to the list in order to maintain position
            continue

            actual_word = itemgetter(*word_index[i])(tokenized_sentence_list[i])
            type_word.append(actual_word)

    return type_word
def expect_sentence(expect_index, wanted_word_list):
    expect_sent = []
    for i in range(len(expect_index)):
        if len(expect_index[i]) == 0:
            continue
        expect_sent.append(wanted_word_list[i])
    return expect_sent

# ---- End of function list ---- #

# Import data #

import numpy as np
import pickle, pprint

# load train_sentence_tagged
pkl_file1 = open('train_sentence_tagged.pkl', 'rb')
train_sentence_tagged = pickle.load(pkl_file1)
pkl_file1.close()
# load test_sentence_tagged
pkl_file2 = open('test_sentence_tagged.pkl', 'rb')
test_sentence_tagged = pickle.load(pkl_file2)
pkl_file2.close()

# CRF Training #
corps, tagids = read_corps(train_sentence_tagged)

featureTS, word_to_tagid, featureT, featureS = getfeatureTS(corps)

K = np.shape(featureTS)[0]  # Total number of features
N = np.shape(corps)[0]  # Total number of sentences
priorfeatureE = getpriorfeatureE(corps, featureTS)  # calculate prior expectation
weights = np.array([1.0/K]*K)  # initial weight on each feature

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)

np.savetxt('crfweightsCar.out', weights, delimiter=',')
# Trained weights
post_weights = np.genfromtxt('crfweightsCar.out', delimiter=',')

######################################
# Plot Convergence of Negloglikelihood#
######################################

import matplotlib.pyplot as plt
plt.rcParams['axes.labelsize'] = 10
plt.rcParams['xtick.labelsize'] = 10
plt.rcParams['ytick.labelsize'] = 10

import codecs
# import neglikelihood value
likelihoodlist = []
with codecs.open('CarNeglikelihood.txt','r') as f:
    for line in f:
        likelihoodlist.append(float(line.split(u':')[-1].split()[0]))
plt.plot(likelihoodlist[:200],'-k')
plt.plot(likelihoodlist[:200],'+r')
plt.title('Convergence of Negative Log-Likelihood using L-BFGS: 100 Iterations')
plt.xlabel('Iteration')
plt.ylabel('Negative Log-Likelihood')

from scipy.stats.kde import gaussian_kde
# Create the kernel, given an array and it will estimate the probability over that values
kde = gaussian_kde(post_weights)

# Calculated the values over which the kernel will be evaluated
dist_space = np.linspace(min(post_weights)-0.01*(max(post_weights)-min(post_weights)), max(post_weights), 400 )

fig,axes = plt.subplots(nrows=2, ncols=1, figsize=(12,10))
plt.subplots_adjust(wspace = None, hspace=0.3)

axes[0].plot(post_weights)
axes[0].set_title('Plot of Predicted Feature Weights - 100 iterations')
axes[0].set_xlabel('Features')
axes[0].set_ylabel('Weights')

axes[1].plot(dist_space, kde(dist_space),'k', marker = u'$\circ$'

axes[1].set_title('Plot of Predicted Weights Probability Density - 100 iterations')
axes[1].set_xlabel('Weights')
axes[1].set_ylabel('Probability Density')

import random

##############################
# Validation #
##############################

# Validation #
from sklearn.metrics import precision_score, recall_score
from sklearn.metrics import f1_score
from sklearn.metrics import accuracy_score

validate_train = train_sentence_tagged.copy()
vali_precision_score = []
vali_recall_score = []
vali_f1_score = []

for vali in range(200):
    random.shuffle(validate_train)
    validate_set = validate_train[:100]
    corps_vali, tagids_vali = read_corps(validate_set)
    path_collection = viterbi_backtracking(corps_vali)

    # True Path with Tag
    path_true_tag_collection = []
    for k in validate_set:
        path_true = []
        for l in k:
            path_true.append(l[1])
        path_true_tag_collection.append(path_true)

    # Predicted Path with Tag
    path_predict_tag_collection = []
    for k in path_collection:
        tag_predict = []
        for l in k:
            tag_predict.append(list(tagids.keys())[list(tagids.values()).index(l[1])])
        path_predict_tag_collection.append(tag_predict)
values().index(1))
    path_predict_tag_collection.append(tag_predict)

    path_true_list = [item for sublist in
                     path_true_tag_collection for item in sublist]
    path_predict_list = [item for sublist in
                         path_predict_tag_collection for item in sublist]

    # Create collection of evaluation metric scores for validation
    vali_precision_score.append(precision_score(path_true_list,
                                                 path_predict_list, average='macro'))
    vali_recall_score.append(recall_score(path_true_list,
                                            path_predict_list, average='macro'))
    vali_f1_score.append(f1_score(path_true_list,
                                  path_predict_list, average='macro'))

    # Combine 3 metrics into 1 dataframe
    import pandas as pd
    vali_performance = pd.DataFrame(np.column_stack([vali_precision_score, vali_recall_score, vali_f1_score]),
                                     columns=['Precision', 'Recall', 'F1_score'])

    vali_performance.to_csv("vali_performance.csv", index=False)
    vali_performance.mean() # Precision
    # Recall
    # F1_score
    vali_performance.std() # Precision
    # Recall
# F1_score

# Histogram of measures
import matplotlib.pyplot as plt
vali_hist = vali_performance.hist(bins=40, grid=False, figsize=(8,10), layout=(3,1), sharex=True, color='#416eaf', zorder=2, rwidth=0.9)

for i, x in enumerate(vali_hist):
    # Switch off ticks
    x.tick_params(axis="both", which="both", bottom="off", top="off", labelbottom="on", left="off", right="off", labelleft="on")

    # Draw horizontal axis lines
    vals = x.get_yticks()
    for tick in vals:
        x.axhline(y=tick, linestyle='dashed', alpha=0.4, color='####eeeee', zorder=1)

    # Set x-axis label
    x.set_xlabel("Measurement Level", labelpad=20, weight='bold', size=12)

    # Set y-axis label
    if i == 1:
        x.set_ylabel("Counts", labelpad=50, weight='bold', size=100)
# Format y-axis label
x.yaxis.set_major_formatter(plt.ticker.StrMethodFormatter('{x :,.g}'))

t.tick_params(axis='x', rotation=0)

# Prediction#

# post_weights
corps_test, tagids_test = read_corps(test_sentence_tagged)
path_collection = viterbi_backtracking(corps_test)

# Calculate Mismatch#

# since tagids_test is different from tagids from training,
# so replace tagid with true tags

# True Path with Tag
path_true_tag_collection = []
for k in test_sentence_tagged:
    path_true = []
    for l in k:
        ...
path_true.append(l[1])

path_true_tag_collection.append(path_true)

# Predicted Path with Tag
path_predict_tag_collection = []

for k in path_collection:
    tag_predict = []
    for l in k:
        tag_predict.append(list(tagids.keys())[list(tagids.values()).index(l)])

    path_predict_tag_collection.append(tag_predict)

# Confusion Matrix
from sklearn.metrics import confusion_matrix

# convert to list structure
path_true_list = [item for sublist in path_true_tag_collection
                 for item in sublist]

path_predict_list = [item for sublist in path_predict_tag_collection
                     for item in sublist]

labels = list(set(path_true_list+path_predict_list))

conf_mx = confusion_matrix(path_true_list, path_predict_list,
                            labels)

# Print confusion matrix
print_cm(conf_mx, labels)

# output to Confusion_matrix.xlsx
# read in confusion matrix data as dataframe
conf_m_df = pd.read_excel('Confusion_matrix.xlsx')

# Plot confusion matrix
plot_confusion_matrix(cm = conf_m_df.values, normalize = False,
                      target_names = labels, title = "Confusion Matrix")

#################################################################
# Plot of Errors #
#################################################################

error_mx = conf_mx.copy()
np.fill_diagonal(error_mx, 0) # fill diagonal with 0s to keep errors only
print_cm(error_mx, labels)

# save as Error_matrix.xlsx
Err_m_df = pd.read_excel('Error_matrix.xlsx')
plot_confusion_matrix(cm = Err_m_df.values, normalize = False,
                      target_names = labels, title = "Error Matrix")

# Normalized Errors
row_sums = conf_mx.sum(axis=1, keepdims=True) # col: axis=0
norm_conf_mx = conf_mx/row_sums
np.fill_diagonal(norm_conf_mx, 0) # fill diagonal with 0s to keep errors only
print_cm(norm_conf_mx, labels)

# save as Norm_Error_matrix.xlsx
Err_m_df = pd.read_excel('Norm_Error_matrix.xlsx')
plot_confusion_matrix(cm = Err_m_df.values, normalize = False, target_names = labels, title = "Normalized Error Matrix")

# Calculate Precision, Recall, F1, Accuracy#

test_precision_score_score = precision_score(path_true_list, path_predict_list, average='macro')
test_precision_score_score = precision_score(path_true_list, path_predict_list, average='micro')
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','JJJS','CD','VB','PRP','MD','NN','JJR','DT','IN','WDT','WP','RP','VBZ','RB','POS','#','PRP$'], average=None) # for each label

test_recall_score = recall_score(path_true_list, path_predict_list, average='macro')
test_recall_score = recall_score(path_true_list, path_predict_list, average='micro')
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','JJJS','CD','VB','PRP','MD','NN','JJR','DT','IN','WDT','WP','RP','VBZ','RB','POS','#','PRP$'], average=None) # for each label

test_f1_score = f1_score(path_true_list, path_predict_list,
test_f1_score = f1_score(path_true_list, path_predict_list, average='micro')

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

accuracy_score(path_true_list, path_predict_list) # overall accuracy

# Performance of NLTK’s Baseline Tagger #

# load default_nltk_test_sentence_tagged
pkl_file2 = open('default_nltk_test_sentence_tagged.pkl', 'rb')
default_nltk_test_sentence_tagged = pickle.load(pkl_file2)
pkl_file2.close()

# True Path with Tag
path_true_tag_collection = []
for k in test_sentence_tagged:
    path_true = []
    for l in k:
        path_true.append(l[1])
    path_true_tag_collection.append(path_true)
# Predicted Path with Tag from NLTK
path_predict_tag_collection = []
for k in default_nltk_test_sentence_tagged:
    path_nltk = []
    for l in k:
        path_nltk.append(l[1])
    path_predict_tag_collection.append(path_nltk)

path_true_list = [item for sublist in path_true_tag_collection
                 for item in sublist]
path_predict_list = [item for sublist in
                     path_predict_tag_collection for item in sublist]

# Evaluation
nltk.precision_score = []
nltk_recall_score = []
nltk_f1_score = []

# create collection of validation metric scores
nltk_precision_score = precision_score(path_true_list,
                                        path_predict_list, average='macro')
nltk_recall_score = recall_score(path_true_list,
                                  path_predict_list, average='macro')
nltk_f1_score = f1_score(path_true_list, path_predict_list,
                          average='macro')

# ---- End of Model Training and Evaluation ---- #
nltk.help.upenn_tagset() # get NLTK treebank tags for reference

# Define tags wanted
wanted = ['NN', 'NNS','JJ', 'JJR', 'JJS']

process_test_sentence = []
with open('Process_CarTesting.txt') as inputfile:
    for line in inputfile:
        process_test_sentence.append(line)

# Tokenize test sentences

test_sentence_tokenized = []
for i in process_test_sentence:
    test_sentence_tokenized.append(nltk.word_tokenize(i.lower()))

# save image

output2 = open('test_sentence_tokenized.pkl', 'wb')
pickle.dump(test_sentence_tokenized, output2)
output2.close()

# load test_sentence_tokenized

pkl_file2 = open('test_sentence_tokenized.pkl', 'rb')
test_sentence_tokenized = pickle.load(pkl_file2)
pkl_file2.close()

# Find the position of corresponding word POS in each test sentence
wanted_index = word_index_extractor(wanted, path_predict_tag_collection)

# Extract word paired with index
wanted_word = word_extractor(wanted_index, test_sentence_tokenized)

# save image
output2 = open('wanted_word.pkl', 'wb')
pickle.dump(wanted_word, output2)
output2.close()

# load wanted_word
pkl_file2 = open('wanted_word.pkl', 'rb')
wanted_word = pickle.load(pkl_file2)
pkl_file2.close()

# Extract sentences with expect word #
# e.g. transmission/transmissions, quality, seat/seats/seating, style/styling, interior/interiors, exterior/exterior, gas/mileage/mpg/mpgs, engine
expect_word = ['transmission', 'transmissions']

expect_index = word_index_extractor(expect_word, wanted_word)

# Output summarized sentences that contain wanted words
expect_sent = expect_sentence(expect_index, wanted_word)