Comparison of NBC, LR and SVM for Yelp Review Classification

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CS 57300 Homework 3

This is almost a couple of hours late submission.

1 Introduction

In this report we discuss the three very popular classifiers for the task of yelp review classification. In particular we discuss the naive bayes, logistic regression and support vector machine classification algorithms.

What follows are the two sections. The next section deals with the Analysis 1 of the homework 3 handout. And the final section discusses the Analysis 2 of the same handout.

2 Analysis 1

2.1 Learning Curves

The plot of results is shown in Figure 1. On x-axis we vary the training set sizes. Instead of percents, we have plotted the actual number of training set examples used to learn the model. On y-axis is the zero one loss. We have three plots — one for each model. The blue plot is for logistic regression, the orange for support vector machine, and the green for naive bayes classifier. The vertical bars show the standard error calculated as described in the homework handout. The values of zero one loss for each of the six training set size averaged accross 10 fold for each of the three models is given below:

average loss for LR = [0.3025, 0.172, 0.123, 0.1045, 0.098, 0.0645]
average loss for SVM = [0.3015, 0.1854, 0.128, 0.1094, 0.1020, 0.073]
average loss for NBC = [0.43499, 0.352, 0.269, 0.2315, 0.1695, 0.1075]

And the respective standard error values are:
standard error for LR = [0.007, 0.0051, 0.0042, 0.0021, 0.00219, 0.001]
standard error for SVM = [0.0075, 0.0049, 0.0039, 0.0026, 0.0023, 0.00143]
standard error for NBC = [0.00570, 0.01027, 0.01323, 0.0112, 0.00736, 0.00448]

These average and standard error values are calculated from the following zero one loss values calculated for each model for training set size for each of the 10 folds. Notice that the horizontal = bar separated the results for each training set size. The zero one losses present within two horizontal = bars belong to the different fold for a specific training set size.

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ZERO-ONE-LOSS-LR 0.26 ZERO-ONE-LOSS-SVM 0.27 ZERO-ONE-LOSS-NBC 0.42 ZERO-ONE-LOSS-LR 0.345 ZERO-ONE-LOSS-SVM 0.335 ZERO-ONE-LOSS-NBC 0.415 ZERO-ONE-LOSS-LR 0.245 ZERO-ONE-LOSS-SVM 0.205 ZERO-ONE-LOSS-NBC 0.465 ZERO-ONE-LOSS-LR 0.295 ZERO-ONE-LOSS-SVM 0.26 ZERO-ONE-LOSS-NBC 0.325 ZERO-ONE-LOSS-LR 0.39 ZERO-ONE-LOSS-SVM 0.41 ZERO-ONE-LOSS-NBC 0.445 ZERO-ONE-LOSS-LR 0.37 ZERO-ONE-LOSS-SVM 0.36 ZERO-ONE-LOSS-NBC 0.36 ZERO-ONE-LOSS-LR 0.245 ZERO-ONE-LOSS-SVM 0.26 ZERO-ONE-LOSS-NBC 0.435 ZERO-ONE-LOSS-LR 0.195 ZERO-ONE-LOSS-SVM 0.2 ZERO-ONE-LOSS-NBC 0.455 ZERO-ONE-LOSS-LR 0.445 ZERO-ONE-LOSS-SVM 0.42 ZERO-ONE-LOSS-NBC 0.52 ZERO-ONE-LOSS-LR 0.235 ZERO-ONE-LOSS-SVM 0.295 ZERO-ONE-LOSS-NBC 0.51
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ZERO-ONE-LOSS-LR 0.2 ZERO-ONE-LOSS-SVM 0.27 ZERO-ONE-LOSS-NBC 0.39 ZERO-ONE-LOSS-LR 0.18 ZERO-ONE-LOSS-SVM 0.2 ZERO-ONE-LOSS-NBC 0.44 ZERO-ONE-LOSS-LR 0.175 ZERO-ONE-LOSS-SVM 0.17 ZERO-ONE-LOSS-NBC 0.445 ZERO-ONE-LOSS-LR 0.24 ZERO-ONE-LOSS-SVM 0.22 ZERO-ONE-LOSS-NBC 0.4 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-SVM

0.115 ZERO-ONE-LOSS-NBC 0.12 ZERO-ONE-LOSS-LR 0.12 ZERO-ONE-LOSS-SVM 0.145 ZERO-ONE-LOSS-NBC 0.385 ZERO-ONE-LOSS-LR 0.255 ZERO-ONE-LOSS-SVM 0.245 ZERO-ONE-LOSS-NBC 0.335 ZERO-ONE-LOSS-LR 0.17 ZERO-ONE-LOSS-SVM 0.195 ZERO-ONE-LOSS-NBC 0.36 ZERO-ONE-LOSS-LR 0.185 ZERO-ONE-LOSS-SVM 0.18 ZERO-ONE-LOSS-NBC 0.445 ZERO-ONE-LOSS-LR 0.09 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.205
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ZERO-ONE-LOSS-LR 0.145 ZERO-ONE-LOSS-SVM 0.125 ZERO-ONE-LOSS-NBC 0.35 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.39 ZERO-ONE-LOSS-LR 0.155 ZERO-ONE-LOSS-SVM 0.165 ZERO-ONE-LOSS-NBC 0.455 ZERO-ONE-LOSS-LR 0.07 ZERO-ONE-LOSS-SVM 0.095 ZERO-ONE-LOSS-NBC 0.23 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.12 ZERO-ONE-LOSS-NBC 0.18 ZERO-ONE-LOSS-LR 0.055 ZERO-ONE-LOSS-SVM 0.065 ZERO-ONE-LOSS-NBC 0.08 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.185 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.135 ZERO-ONE-LOSS-NBC 0.19 ZERO-ONE-LOSS-LR 0.215 ZERO-ONE-LOSS-SVM 0.22 ZERO-ONE-LOSS-NBC 0.485 ZERO-ONE-LOSS-LR 0.135 ZERO-ONE-LOSS-SVM 0.125 ZERO-ONE-LOSS-NBC 0.15
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ZERO-ONE-LOSS-LR 0.08 ZERO-ONE-LOSS-SVM 0.075 ZERO-ONE-LOSS-NBC 0.06 ZERO-ONE-LOSS-LR 0.095 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.135 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.125 ZERO-ONE-LOSS-NBC 0.415 ZERO-ONE-LOSS-LR 0.085 ZERO-ONE-LOSS-SVM 0.085 ZERO-ONE-LOSS-NBC 0.075 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-SVM 0.105 ZERO-ONE-LOSS-NBC 0.2 ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.275 ZERO-ONE-LOSS-LR 0.075 ZERO-ONE-LOSS-SVM 0.095 ZERO-ONE-LOSS-NBC 0.23 ZERO-ONE-LOSS-LR 0.145 ZERO-ONE-LOSS-SVM 0.175 ZERO-ONE-LOSS-NBC 0.28 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.385 ZERO-ONE-LOSS-LR 0.13 ZERO-ONE-LOSS-SVM 0.12 ZERO-ONE-LOSS-NBC 0.26
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ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-SVM 0.11 ZERO-ONE-LOSS-NBC 0.26 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.07 ZERO-ONE-LOSS-LR 0.095 ZERO-ONE-LOSS-SVM 0.09 ZERO-ONE-LOSS-NBC 0.125 ZERO-ONE-LOSS-LR 0.07 ZERO-ONE-LOSS-SVM 0.075 ZERO-ONE-LOSS-NBC 0.12 ZERO-ONE-LOSS-LR 0.145 ZERO-ONE-LOSS-SVM 0.145 ZERO-ONE-LOSS-NBC 0.225 ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.24 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.095 ZERO-ONE-LOSS-NBC 0.095 ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.23 ZERO-ONE-LOSS-LR 0.085 ZERO-ONE-LOSS-SVM 0.075 ZERO-ONE-LOSS-NBC 0.25 ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-SVM 0.12 ZERO-ONE-LOSS-NBC 0.08
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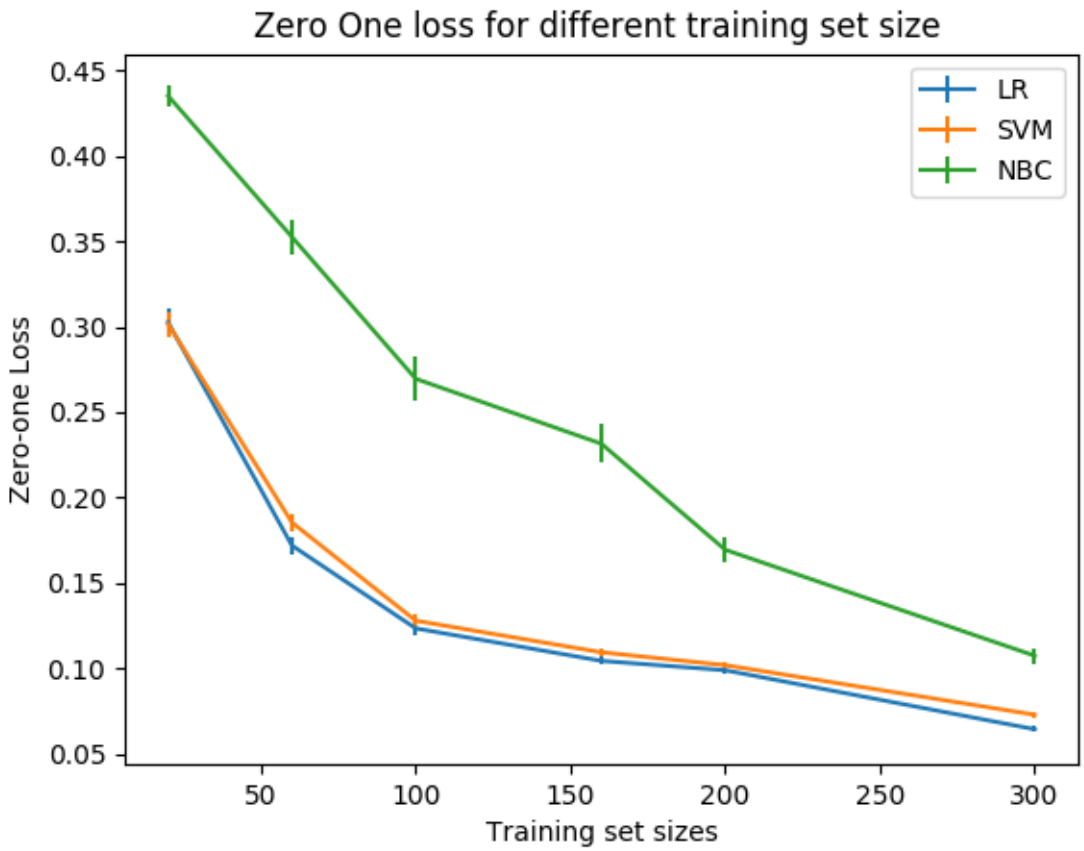
ZERO-ONE-LOSS-LR 0.055 ZERO-ONE-LOSS-SVM 0.06 ZERO-ONE-LOSS-NBC 0.19 ZERO-ONE-LOSS-LR 0.09 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.065 ZERO-ONE-LOSS-LR 0.04 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.15 ZERO-ONE-LOSS-LR 0.07 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.115 ZERO-ONE-LOSS-LR 0.095 ZERO-ONE-LOSS-SVM 0.085 ZERO-ONE-LOSS-NBC 0.155 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.065 ZERO-ONE-LOSS-LR 0.07 ZERO-ONE-LOSS-SVM 0.06 ZERO-ONE-LOSS-NBC 0.085 ZERO-ONE-LOSS-LR 0.045 ZERO-ONE-LOSS-SVM 0.06 ZERO-ONE-LOSS-NBC 0.055 ZERO-ONE-LOSS-LR 0.05 ZERO-ONE-LOSS-SVM 0.05 ZERO-ONE-LOSS-NBC 0.13 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-SVM 0.075 ZERO-ONE-LOSS-NBC 0.065



2.2 Hypothesis

Let's compare the two algorithms LR and NBC.

Null hypothesis is that the LR and NBC are equivalent in terms of performance. It is assumed to be true. While the alternative hypothesis is that LR and NBC zero one losses are significantly different.

2.3 Discussion to test the hypothesis

It is obvious from the plot of Figure 1 of average zero one losses and standard errors of the two algorithms (LR and NBC) that their performances are very different from each other. This is because in none of the training set sizes the error bars in the plot for the two algorithms are overlapping each other as the plots are very far apart from each other.

Nonetheless we perform paired t-test to compare their performances and to figure out whether the differences between performances are statistically significant. The t-test are performed using online tool called GraphPad. Following are the results for each training set size.

For 1% training set size: The two-tailed P value equals 0.0025 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.13250. 95% confidence interval of this difference: From -0.20495 to -0.06005

For 3% training set size: The two-tailed P value equals 0.0001 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.18050 . 95% confidence interval of this difference: From -0.24367 to -0.11733

For 5% training set size: The two-tailed P value equals 0.0023 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.14600. 95% confidence interval of this difference: From -0.22458 to -0.06742

For 8% training set size: The two-tailed P value equals 0.0045 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.12700 95% confidence interval of this difference: From -0.20335 to -0.05065

For 10% training set size: The two-tailed P value equals 0.0127 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.07050 95% confidence interval of this difference: From -0.12196 to -0.01904

For 15% training set size: The two-tailed P value equals 0.0292 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR minus NBC equals -0.04300 95% confidence interval of this difference: From -0.08056 to -0.00544

Since the difference of the zero one losses for the two algorithms are statistically significant for all the training set sizes, we conclude that the alternative hypothesis is true and null hypothesis is rejected.

3 Analysis 2

3.1 Learning Curves

Adding one more value to the feature to make it three value, we perform the experiments for the three models (LR, SVM, and NBC) and plot the reuslting learning curves as shown in Figure 2.

On x-axis we vary the training set sizes. Instead of percents, we have plotted the actual number of training set examples used to learn the model. On y-axis is the zero one loss. We have three plots — one for each model. The blue plot is for logistic regression, the orange for support vector machine, and the green for naive bayes classifier. The vertical bars show the standard error calculated as described in the homework handout. The values of zero one loss for each of the six training set size averaged accross 10 fold for each of the three models is given below:

=======LR======
avg = [0.3125, 0.169, 0.1259, 0.0905, 0.08149, 0.06299]
se = [0.00822, 0.0021, 0.00174, 0.0018, 0.002214, 0.00148]
=======SVM======
avg=[0.3170, 0.1635, 0.1389, 0.101, 0.087, 0.0725]
se = [0.006438, 0.0024601, 0.002457, 0.00304, 0.001584, 0.00184]
=======NBC======
avg = [0.4779999, 0.4255, 0.3889, 0.3355, 0.276499, 0.177]
se = [0.0067, 0.008664, 0.0069, 0.010, 0.0093, 0.008]
=======LR2val======
avg = [0.3290, 0.1859, 0.136, 0.0915, 0.083, 0.075]
se = [0.007986, 0.00254, 0.00178, 0.0018, 0.00152, 0.0011]

The above values are calculated from the following zero one loss values for varying training set size each having10 folds:

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ZERO-ONE-LOSS-LR 0.2 ZERO-ONE-LOSS-LR-2val 0.27 ZERO-ONE-LOSS-SVM 0.275 ZERO-ONE-LOSS-NBC 0.57 ZERO-ONE-LOSS-LR 0.41 ZERO-ONE-LOSS-LR-2val 0.41 ZERO-ONE-LOSS-SVM 0.355 ZERO-ONE-LOSS-NBC 0.495 ZERO-ONE-LOSS-LR 0.445 ZERO-ONE-LOSS-LR-2val 0.47 ZERO-ONE-LOSS-SVM 0.405 ZERO-ONE-LOSS-NBC 0.48 ZERO-ONE-LOSS-LR 0.32 ZERO-ONE-LOSS-LR-2val 0.34 ZERO-ONE-LOSS-SVM 0.31 ZERO-ONE-LOSS-NBC 0.455 ZERO-ONE-LOSS-LR 0.21 ZERO-ONE-LOSS-LR-2val 0.255 ZERO-ONE-LOSS-SVM 0.205 ZERO-ONE-LOSS-NBC 0.47 ZERO-ONE-LOSS-LR 0.295 ZERO-ONE-LOSS-LR-2val 0.265 ZERO-ONE-LOSS-SVM 0.35 ZERO-ONE-LOSS-NBC 0.38 ZERO-ONE-LOSS-LR 0.285 ZERO-ONE-LOSS-LR-2val 0.27 ZERO-ONE-LOSS-SVM 0.27 ZERO-ONE-LOSS-NBC 0.55 ZERO-ONE-LOSS-LR 0.41 ZERO-ONE-LOSS-LR-2val 0.45 ZERO-ONE-LOSS-SVM 0.41 ZERO-ONE-LOSS-NBC 0.5 ZERO-ONE-LOSS-LR 0.23 ZERO-ONE-LOSS-LR-2val 0.255 ZERO-ONE-LOSS-SVM 0.245 ZERO-ONE-LOSS-NBC 0.345 ZERO-ONE-LOSS-LR 0.32 ZERO-ONE-LOSS-LR-2val 0.305 ZERO-ONE-LOSS-SVM 0.345 ZERO-ONE-LOSS-NBC 0.535

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ZERO-ONE-LOSS-LR 0.16 ZERO-ONE-LOSS-LR-2val 0.165 ZERO-ONE-LOSS-SVM 0.185 ZERO-ONE-LOSS-NBC 0.56 ZERO-ONE-LOSS-LR 0.135 ZERO-ONE-LOSS-LR-2val 0.155 ZERO-ONE-LOSS-SVM 0.135 ZERO-ONE-LOSS-NBC 0.42 ZERO-ONE-LOSS-LR 0.205 ZERO-ONE-LOSS-LR-2val 0.205 ZERO-ONE-LOSS-SVM 0.2 ZERO-ONE-LOSS-NBC 0.475 ZERO-ONE-LOSS-LR 0.195 ZERO-ONE-LOSS-LR-2val 0.22 ZERO-ONE-LOSS-SVM 0.175 ZERO-ONE-LOSS-NBC 0.49 ZERO-ONE-LOSS-LR 0.17 ZERO-ONE-LOSS-LR-2val 0.195 ZERO-ONE-LOSS-SVM 0.155 ZERO-ONE-LOSS-NBC 0.37 ZERO-ONE-LOSS-LR 0.18 ZERO-ONE-LOSS-LR-2val 0.235 ZERO-ONE-LOSS-SVM 0.175 ZERO-ONE-LOSS-NBC 0.45 ZERO-ONE-LOSS-LR 0.14 ZERO-ONE-LOSS-LR-2val 0.16 ZERO-ONE-LOSS-SVM 0.12 ZERO-ONE-LOSS-NBC 0.34 ZERO-ONE-LOSS-LR 0.165 ZERO-ONE-LOSS-LR-2val 0.175 ZERO-ONE-LOSS-SVM 0.18 ZERO-ONE-LOSS-NBC 0.495 ZERO-ONE-LOSS-LR 0.185 ZERO-ONE-LOSS-LR-2val 0.17 ZERO-ONE-LOSS-SVM 0.175 ZERO-ONE-LOSS-NBC 0.415 ZERO-ONE-LOSS-LR 0.155 ZERO-ONE-LOSS-LR-2val 0.18 ZERO-ONE-LOSS-SVM 0.135 ZERO-ONE-LOSS-NBC 0.24

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ZERO-ONE-LOSS-LR 0.11 ZERO-ONE-LOSS-LR-2val 0.15 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.405 ZERO-ONE-LOSS-LR 0.125 ZERO-ONE-LOSS-LR-2val 0.11 ZERO-ONE-LOSS-SVM 0.13 ZERO-ONE-LOSS-NBC 0.385 ZERO-ONE-LOSS-LR 0.11 ZERO-ONE-LOSS-LR-2val 0.11 ZERO-ONE-LOSS-SVM 0.13 ZERO-ONE-LOSS-NBC 0.445 ZERO-ONE-LOSS-LR 0.16 ZERO-ONE-LOSS-LR-2val 0.16 ZERO-ONE-LOSS-SVM 0.205 ZERO-ONE-LOSS-NBC 0.44 ZERO-ONE-LOSS-LR 0.135 ZERO-ONE-LOSS-LR-2val 0.13 ZERO-ONE-LOSS-SVM 0.135 ZERO-ONE-LOSS-NBC 0.425 ZERO-ONE-LOSS-LR 0.125 ZERO-ONE-LOSS-LR-2val 0.145 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.37 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-LR-2val 0.12 ZERO-ONE-LOSS-SVM 0.135 ZERO-ONE-LOSS-NBC 0.205 ZERO-ONE-LOSS-LR 0.11 ZERO-ONE-LOSS-LR-2val 0.13 ZERO-ONE-LOSS-SVM 0.13 ZERO-ONE-LOSS-NBC 0.445 ZERO-ONE-LOSS-LR 0.13 ZERO-ONE-LOSS-LR-2val 0.16 ZERO-ONE-LOSS-SVM 0.14 ZERO-ONE-LOSS-NBC 0.345 ZERO-ONE-LOSS-LR 0.15 ZERO-ONE-LOSS-LR-2val 0.145 ZERO-ONE-LOSS-SVM

0.155 ZERO-ONE-LOSS-NBC 0.425

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ZERO-ONE-LOSS-LR 0.085 ZERO-ONE-LOSS-LR-2val 0.085 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.255 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-LR-2val 0.095 ZERO-ONE-LOSS-SVM 0.11 ZERO-ONE-LOSS-NBC 0.37 ZERO-ONE-LOSS-LR 0.05 ZERO-ONE-LOSS-LR-2val 0.05 ZERO-ONE-LOSS-SVM 0.04 ZERO-ONE-LOSS-NBC 0.26 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-LR-2val 0.075 ZERO-ONE-LOSS-SVM 0.07 ZERO-ONE-LOSS-NBC 0.065 ZERO-ONE-LOSS-LR 0.085 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.16 ZERO-ONE-LOSS-NBC 0.38 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-LR-2val 0.11 ZERO-ONE-LOSS-SVM 0.105 ZERO-ONE-LOSS-NBC 0.395 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-LR-2val 0.095 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.37 ZERO-ONE-LOSS-LR 0.095 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.125 ZERO-ONE-LOSS-NBC 0.37 ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-LR-2val 0.11 ZERO-ONE-LOSS-SVM 0.085 ZERO-ONE-LOSS-NBC 0.43 ZERO-ONE-LOSS-LR 0.11 ZERO-ONE-LOSS-LR-2val 0.115 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.46

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ZERO-ONE-LOSS-LR 0.115 ZERO-ONE-LOSS-LR-2val 0.11 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.31 ZERO-ONE-LOSS-LR 0.075 ZERO-ONE-LOSS-LR-2val 0.075 ZERO-ONE-LOSS-SVM 0.09 ZERO-ONE-LOSS-NBC 0.33 ZERO-ONE-LOSS-LR 0.04 ZERO-ONE-LOSS-LR-2val 0.06 ZERO-ONE-LOSS-SVM 0.055 ZERO-ONE-LOSS-NBC 0.275 ZERO-ONE-LOSS-LR 0.09 ZERO-ONE-LOSS-LR-2val 0.085 ZERO-ONE-LOSS-SVM 0.11 ZERO-ONE-LOSS-NBC 0.255 ZERO-ONE-LOSS-LR 0.105 ZERO-ONE-LOSS-LR-2val 0.095 ZERO-ONE-LOSS-SVM 0.095 ZERO-ONE-LOSS-NBC 0.355 ZERO-ONE-LOSS-LR 0.08 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.09 ZERO-ONE-LOSS-NBC 0.105 ZERO-ONE-LOSS-LR 0.1 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.1 ZERO-ONE-LOSS-NBC 0.375 ZERO-ONE-LOSS-LR 0.085 ZERO-ONE-LOSS-LR-2val 0.1 ZERO-ONE-LOSS-SVM 0.085 ZERO-ONE-LOSS-NBC 0.375 ZERO-ONE-LOSS-LR 0.075 ZERO-ONE-LOSS-LR-2val 0.07 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.11 ZERO-ONE-LOSS-LR 0.05 ZERO-ONE-LOSS-LR-2val 0.065 ZERO-ONE-LOSS-SVM 0.065 ZERO-ONE-LOSS-NBC 0.275

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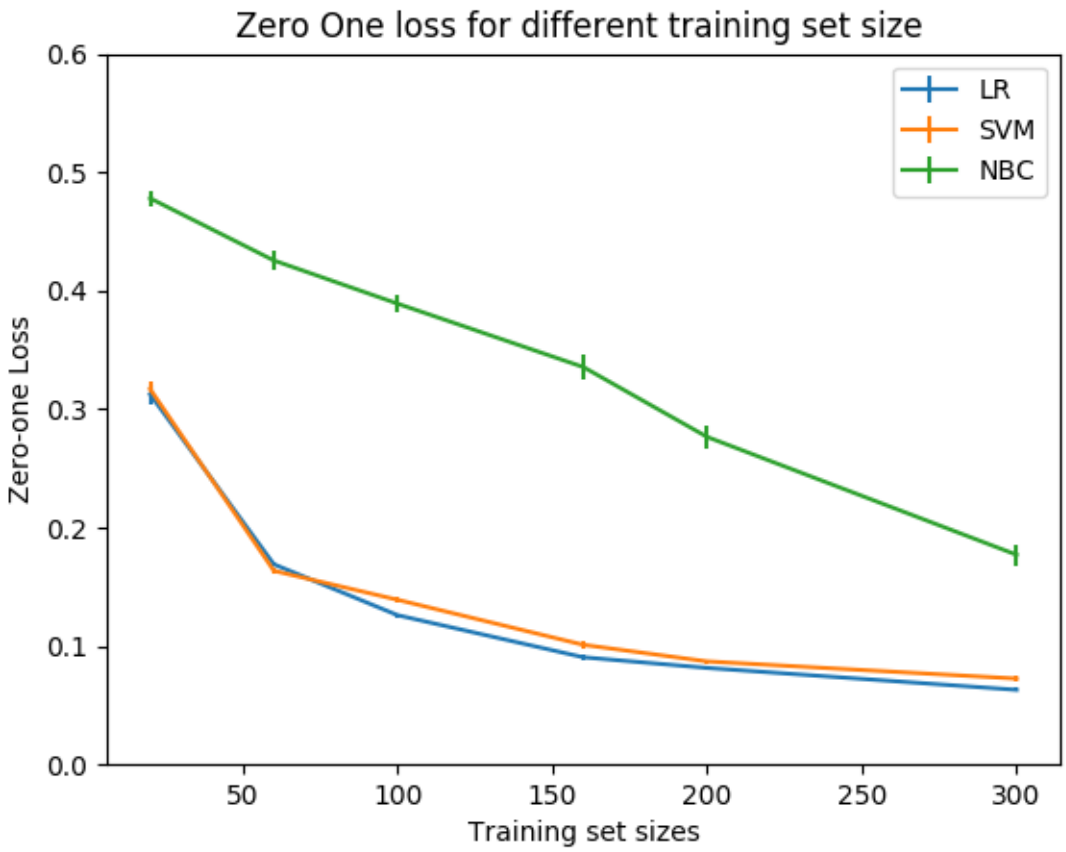
ZERO-ONE-LOSS-LR 0.05 ZERO-ONE-LOSS-LR-2val 0.06 ZERO-ONE-LOSS-SVM 0.065 ZERO-ONE-LOSS-NBC 0.15 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-LR-2val 0.085 ZERO-ONE-LOSS-SVM 0.065 ZERO-ONE-LOSS-NBC 0.23 ZERO-ONE-LOSS-LR 0.045 ZERO-ONE-LOSS-LR-2val 0.06 ZERO-ONE-LOSS-SVM 0.045 ZERO-ONE-LOSS-NBC 0.135 ZERO-ONE-LOSS-LR 0.06 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.075 ZERO-ONE-LOSS-NBC 0.12 ZERO-ONE-LOSS-LR 0.095 ZERO-ONE-LOSS-LR-2val 0.075 ZERO-ONE-LOSS-SVM 0.085 ZERO-ONE-LOSS-NBC 0.16 ZERO-ONE-LOSS-LR 0.075 ZERO-ONE-LOSS-LR-2val 0.075 ZERO-ONE-LOSS-SVM 0.08 ZERO-ONE-LOSS-NBC 0.1 ZERO-ONE-LOSS-LR 0.045 ZERO-ONE-LOSS-LR-2val 0.07 ZERO-ONE-LOSS-SVM 0.055 ZERO-ONE-LOSS-NBC 0.145 ZERO-ONE-LOSS-LR 0.055 ZERO-ONE-LOSS-LR-2val 0.06 ZERO-ONE-LOSS-SVM 0.06 ZERO-ONE-LOSS-NBC 0.23 ZERO-ONE-LOSS-LR 0.075 ZERO-ONE-LOSS-LR-2val 0.09 ZERO-ONE-LOSS-SVM 0.115 ZERO-ONE-LOSS-NBC 0.09 ZERO-ONE-LOSS-LR 0.065 ZERO-ONE-LOSS-LR-2val 0.085 ZERO-ONE-LOSS-SVM



0.08 ZERO-ONE-LOSS-NBC 0.41

3.2 Hypothesis

Let's compare Logistic regression which uses three features (LR-3val) with Logistic regression which uses two features (LR-2val).

Null hypothesis is that both are equivalent in terms of performance. It is assumed to be true. While the alternative hypothesis is that LR-3val and LR-2val zero one losses are significantly different.

3.3 Discussion to test the hypothesis

It can be seen from the average zero one loss and standard error values for LR-3val and LR-2val that the difference is not significant. The standard error values for LR-3val do not overlap with the LR-Binary values.

We perform t-test to compare the performance. The results for different training set sizes are given below:

For 1% training set size: The two-tailed P value equals 0.1296 which is greater than $\alpha = 0.05$. This difference is considered to be NOT statistically significant. The mean of LR-3val minus LR-2val equals -0.01650 . 95% confidence interval of this difference: From -0.03887 to 0.00587

For 3% training set size: The two-tailed P value equals 0.0185 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR-3val minus LR-2val equals

-0.01700 . 95% confidence interval of this difference: From -0.03040 to -0.00360

For 5% training set size: The two-tailed P value equals 0.1066 which is greater than $\alpha = 0.05$. This difference is considered to be NOT statistically significant. The mean of LR-3val minus LR-2val equals -0.01000 . 95% confidence interval of this difference: From -0.02262 to 0.00262

For 8% training set size: The two-tailed P value equals 0.6783 which is greater than $\alpha = 0.05$. This difference is considered to be NOT statistically significant. The mean of LR-3val minus LR-2val equals -0.00100 95% confidence interval of this difference: From -0.00628 to 0.00428

For 10% training set size: The two-tailed P value equals 0.5042 which is greater than $\alpha = 0.05$. This difference is considered to be NOT statistically significant. The mean of LR-3val minus LR-2val equals -0.00250 . 95% confidence interval of this difference: From -0.01063 to 0.00563

For 15% training set size: The two-tailed P value equals 0.0269 which is less than $\alpha = 0.05$. This difference is considered to be statistically significant. The mean of LR-3val minus LR-2val equals -0.01200 95% confidence interval of this difference: From -0.02228 to -0.00172

Since the differences of zero one losses for all the training set sizes (except for 3 and 15%) are NOT statistically significant we conclude that the addition of a new feature does not enhance the algorithm much and the results are comparable. Null hypothesis is true in this case and we accept it.