CS 636 Assignment 4: Image Classification

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Abstract

I train a random forest and a logistic regression classifier on a random sample of 500 example images from each of the classes. I chose to try two methods in order to obtain extra credit for the assignment as well as get an idea of the performance of each with respect to the parameter of interest in my experiments, feature type while I use k-fold cross validation to asses how well each model can generalize.. My results show that the bag of words features, used in field such as NLP and computer vision, are suboptimal compared to the features generated by the AlexNet deep convolutional neural network. Modern advances in image classification make better use of raw image data, generating more useful features as a byproduct.

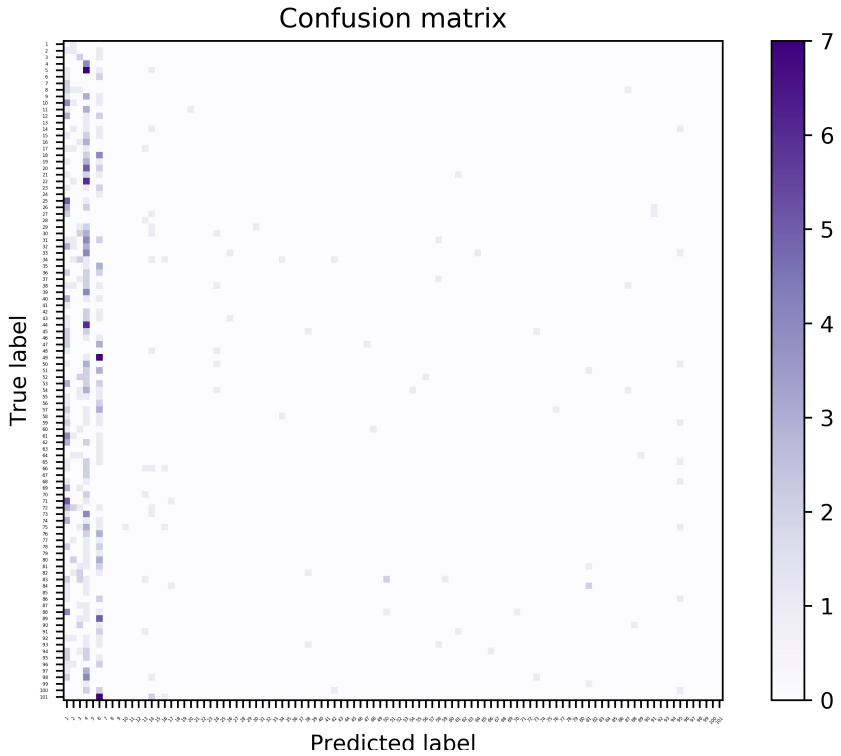
1 Bag of Words

For the bag of words implementation, I aggregate a random subset of the surf features (throwing out examples in which the number of features is less than a threshold specified as a parameter in the make_codebook() function) and then perform k-means (50 clusters, maximum of 300 iterations) to solve for the code book. Then for each of the training examples, I iterate over each surf feature and predict the cluster that the given feature belongs to. I form a histogram over all of the possible clusters, of which there are 50 total as specified in the assignment, then normalize this (as the number of features varies between examples, normalization makes this less relevant) and use this as my feature vector.

1.1 Random Forest

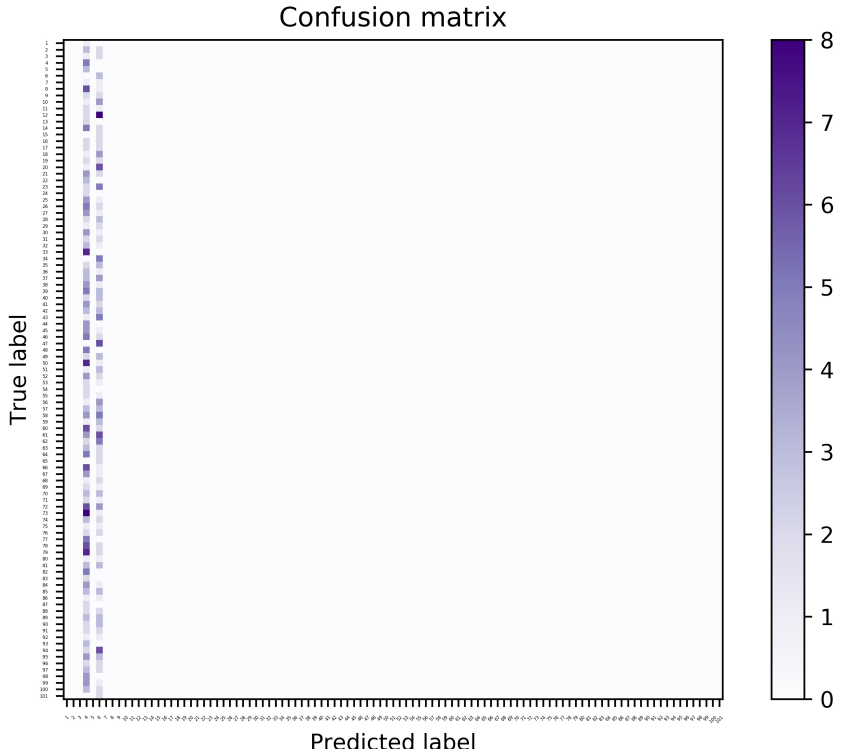
I train a random forest classifier which is provided via the scikit-learn library with $n = 100$ decision stumps, using default settings for all other parameters. I choose this number of trees in order to decrease computation time, I've also found limited marginal gain by increasing the size of the forest (the largest I've tried is $n = 100$ decision stumps). My results give a k-fold cross validation (on the training set, $k = 5$) average accuracy of 34.7%. The random forest is also able to perfectly classify the full training set of 500 examples. Finally the test

accuracy of this method is rather disappointing at 5.0%. The confusion matrix is given below:



1.2 Logistic Regression (Extra Credit)

I train a logistic regression classifier provided via the scikit-learn library with default settings. My results give a k-fold cross validaton (on the training set, k =5) average accuracy of 27%. The logistic regression also gets about a 25% training accuracy on the full training set. Finally, the test accuracy of this method is 1.6% accuracy. The confusion matrix is given below:

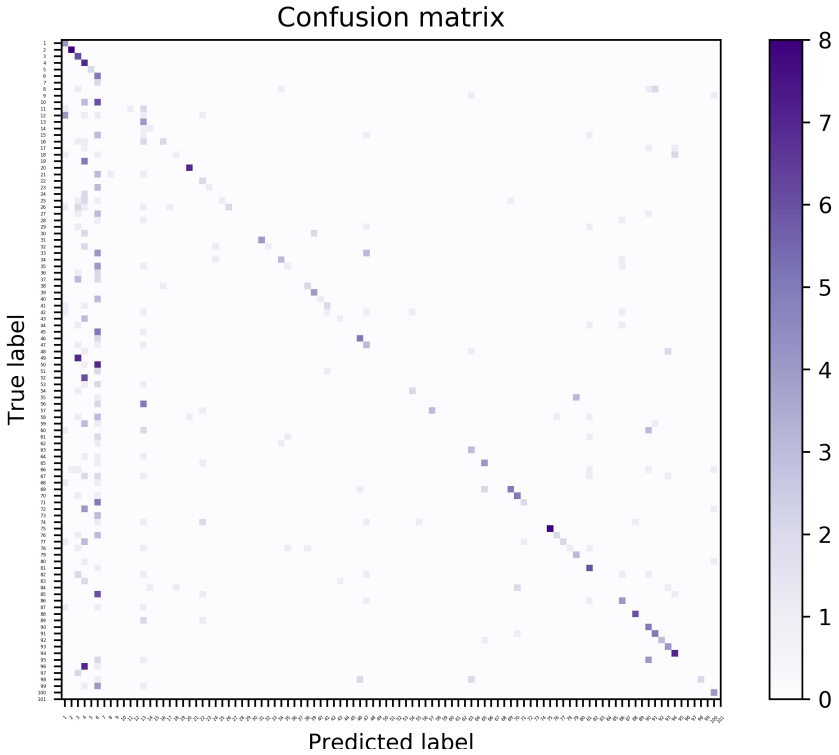


2 Alexnet

Foor the alexnet implementation, I simply use the provided feature vector which is the output of a convolutional layer in the network.

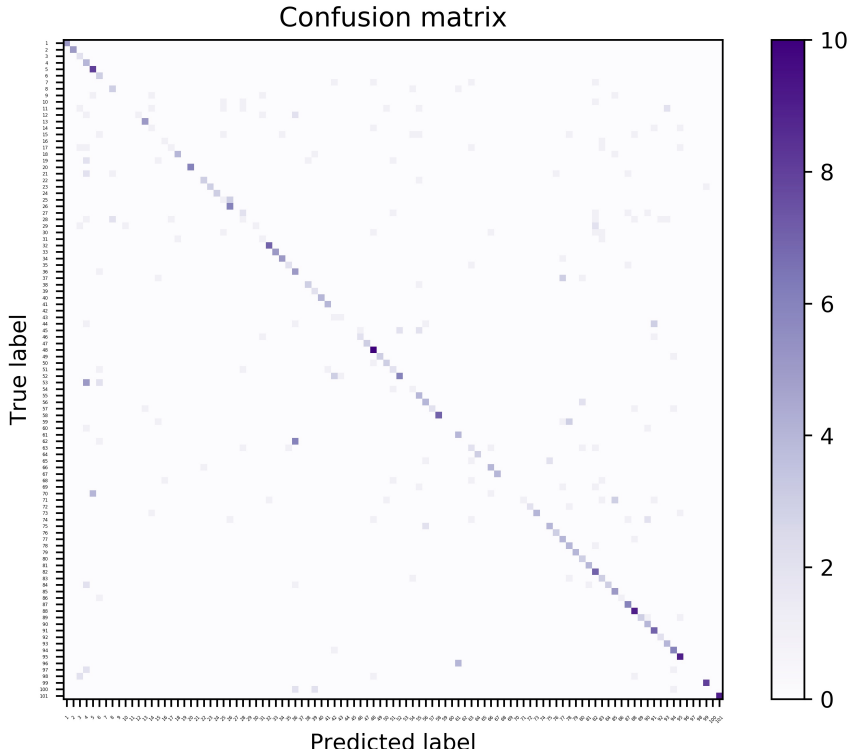
2.1 Random Forest

I train a random forest with $n = 500$ decision stumps. The random forest achieves an average cross validation accuracy of 71% accuracy, while perfectly classifying the full training set, and achieves about 33% accuracy on the test set, which is vastly more impressive than the bag of words counterpart (although I did use a large number of estimators).



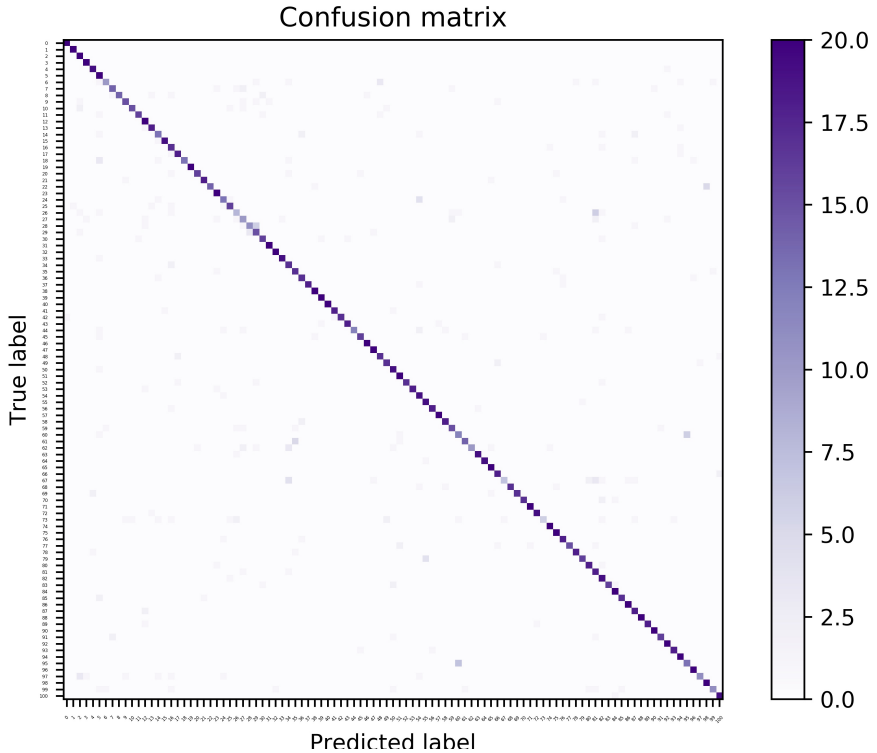
2.2 Logistic Regression(Extra Credit)

I train a logistic regression classifier with default parameters. The logistic classifier achieves an average cross validation accuracy of 81% accuracy, perfectly classifies the full training set, and achieves a testing accuracy of approximately 57.6% accuracy, by far the best result.



3 Dilated Convolutional Network: AlexNet(Extra Extra Credit)

Finally, for extra extra credit, I use Keras to implement a convolutional network on top of the alexNet features with a 1D dilated convolution layer followed by a 1D convolution layer (no dilation) followed by a dropout layer, then finally with a fully connected softmax layer. I use tanh activations for the convolution layers. I use categorical cross entropy as my loss and ADAM with a learning rate of $\alpha = 1e-5$. I train using 5235 images as my training set and 1047 as holdout test during my training. I train the network for 1000 epochs. My results for this implementation vastly outperform the previously mentioned methods with a test accuracy of approximately 85%.



4 Conclusions

Overall, I found the combination of a logistic regression classifier trained with AlexNet features to be the most accurate predictor of the image class. AlexNet is able to generate informative features that are perhaps better at incorporating global information better than the bag of words features, which is a local feature aggregation method. Moreover, logistic regession is a powerful classification tool that can fit many non-linear decision problems and be quite successful.

However with modern deep learning methods, one can easily take the output of a layer in a more powerful network and use as input to another network in order to leverage the features for a different task or to add more complexity without needing to retrain the part of the network that does the heavy lifting in terms of extracting good features. My final implementation of convolutional network with dilated convolution layer vastly outperforms each of my previous methods by a large margin.