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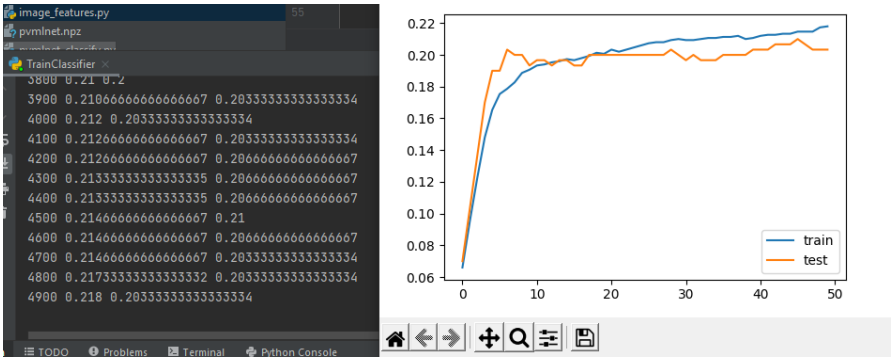
Cake Classification

1) Low-level features

From the predefined implementations in the file image_features.py, the low-level feature vectors were computed.

a) Color Histogram

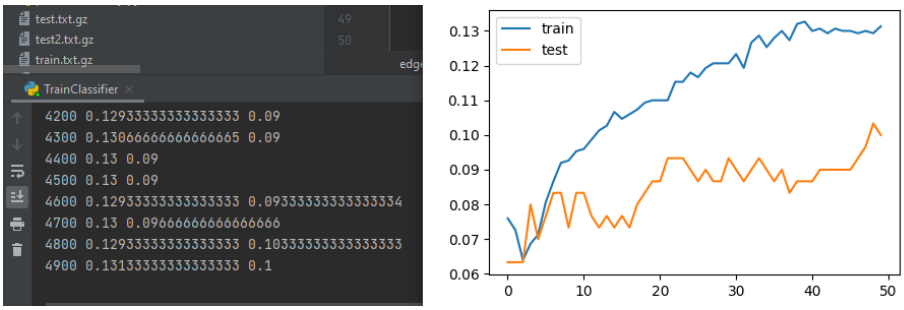
It represents RGB marginal histograms of a color image, where gray-level images of shape (m, n) are first converted to RGB, and histograms are normalized to sum to one.



IT can be concluded that this feature doesn't give good results, where the test accuracy is: 20.3, while the train accuracy is: 21.8.

b) Edge Direction Histogram

The color images are first converted to grayscale, and the histograms are normalized to sum to one.



The results using the feature are worst than the previous feature, where the train accuracy is 13.1 while the test accuracy is 10, and there is a wide difference between both accuracies seen in the plot.

c) other features

The other features didn't give any better results than the previous ones as shown in the results below:

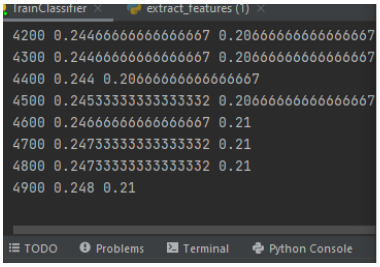
Feature	Train Acc	Test Acc
cooccurrence_matrix	18.6	19.6
Rgb_cooccurrence_matrix	18.86	16.3

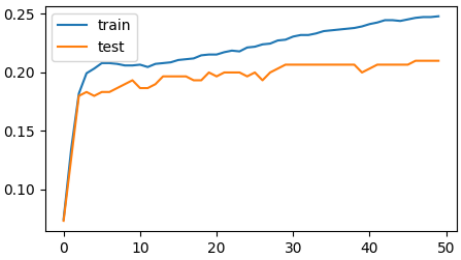
d) Combining features

To achieve better result, combining the low-level features must be done where there are complicated images, such as the Macrons which have different colors and the churros which have different shapes. And it can be done using the following code:

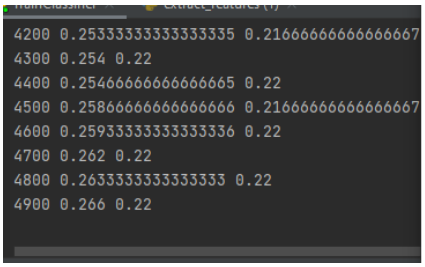
```
features = image_features.color_histogram(image)
features2 = image_features.edge_direction_histogram(image)
features = features.reshape(-1)  # turn the matrix into a vector
features2 = features.reshape(-1)
newfeatures = np.concatenate((features, features2))
all_features.append(newfeatures)
all_labels.append(class_label)
```

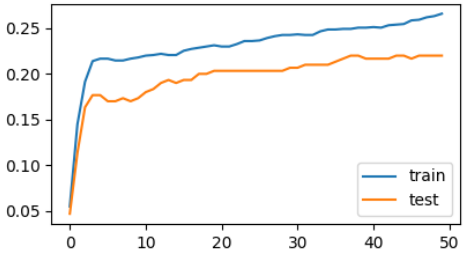
When combining the color histogram feature with the edge direction histogram, the following results were achieved which is better than result obtained from using a single feature.





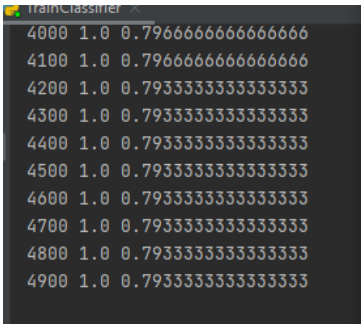
Also, when combining 3 features which are the color histogram, edge direction histogram, and the cooccurrence matrix, the results improved from when using 2 features but not by a lot.

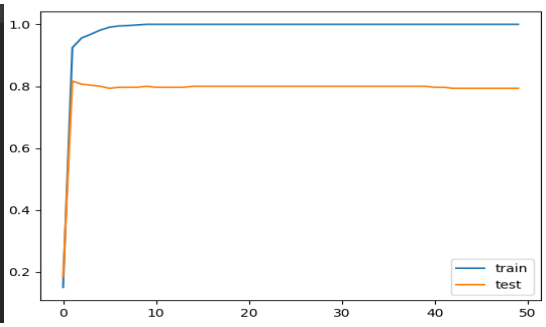




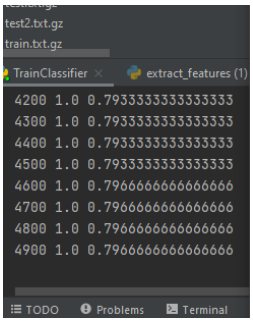
2) Neural features

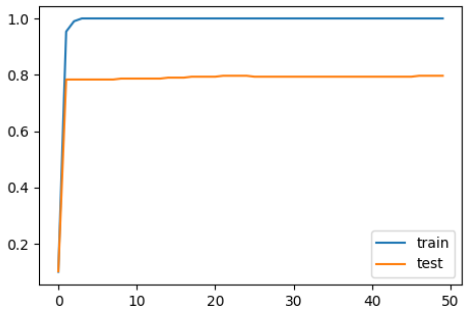
Using the pretrained PVMLNet to extract as features the activations of the last hidden layer, where a pretrained neural was used for saving time. And from observing the results as shown in the figure below (which is without using hidden layers), the accuracy is really good.





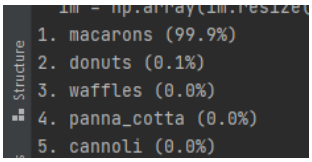
Adding 1 hidden layer with 50 neurons only increased the test accuracy by 0.003 as shown in the figure below:





3) Transfer Learning

With building a new network by replacing the last layer of PVMLNet with the weights of the trained perceptron, the images can be classified with one of the classes, such as the following example, where the image 70102 was chosen from the macarons file:



Then to observe the classification for classes, for each class 2 random files were chosen for classifications, and the results as shown in the table below, where there are classes that were classified correctly with high confidence (like the Apple pie and Donuts, etc.), others were misclassified with little accuracy such as the carrot cake. In the 2nd file for the red velvet cake, it was misclassified as carrot cake with high confidence, which can be understood because the color of the 2 cakes is similar.

Class	1st Attempt (Name of File/ 1st Classification)		2nd Attempt (Name of File/ 1st Classification)	
Apple pie	1355206	Apple Pie (100%)	822817	Apple Pie (99.9%)
Cannoli	96922	Apple Pie (90.4%)	1057676	Ice Cream(97.8%)
Carrot Cake	182175	cannoli (44.1%)	3484336	carrot_cake (99.6%)
Chocolate Cake	1199732	chocolate_cake (100.0%)	881878	chocolate_cake (91.7%)
Chocolate Mousse	640	chocolate_mousse (99.4%)	3549214	chocolate_mousse (100.0%)
Churros	270881	churros (100.0%)	555011	churros (100.0%)
Crème Brulee	335611	creme_brulee (99.8%)	125665	creme_brulee (100.0%)
Cup Cakes	1703900	churros (60.8%)	764042	cup_cakes (86.3%)
Donuts	4919	donuts (100.0%)	673609	donuts (100.0%)
Ice Cream	524372	cup_cakes (78.2%)	2188378	ice_cream (97.9%)
Macarons	307941	macarons (98.6%)	828950	macarons (99.9%)
Panna Cotta	295061	apple_pie (67.6%)	2262238	panna_cotta (94.1%)
Red Velvet Cake	569810	red_velvet_cake (99.7%)	1366031	carrot_cake (99.8%)
Tiramisu	1801190	tiramisu (96.6%)	2746460	tiramisu (100.0%)
Waffles	347105	waffles (100.0%)	734196	waffles (100.0%)

I affirm that this report is the result of my own work and that I did not share any part of it with anyone else except the teacher.