ENSC 813
Spring 2020
Classifying car images in the TCC dataset
User Manual

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April 14, 2020

1 Introduction

This user manual provides general information on how to run the scripts in this project. The *GitHub* repository for this project can be found at https://github.com/AshivDhondea/ENSC813_Project.

2 Scripts

Scripts in this project should be run sequentially, i.e. `main_10_binary_classification_00.py` should be run before `main_11_binary_classification_00.py`.

Exploratory Data Analysis is done in `main_00_eda_00.py`.

Table 1: Binary classification scripts

File name	**Purpose**
main_02_binary_classification_00.py	EDA and undersampling.
main_03_binary_classification_00.py	Model 1. k-fold CrossVal
main_04_binary_classification_00.py	Model 2. k-fold CrossVal
main_05_binary_classification_00.py	Model 3. k-fold CrossVal
main_06_binary_classification_00.py	Model 4. k-fold CrossVal
main_07_binary_classification_00.py	10-fold CrossVal. Benchmarking.
main_08_binary_classification_00.py	Model 1 for Ensembling.
main_09_binary_classification_00.py	Model 2 for Ensembling.
main_10_binary_classification_00.py	Model 3 for Ensembling.
main_11_binary_classification_00.py	Model 4 for Ensembling.
main_12_binary_classification_00.py	Ensembling results from all models.
main_13_binary_classification_00.py	Ensembling results from all models.

Table 2: Multi-classification scripts

File name	**Purpose**
main_19_multiclass_classification_00.py	Pre-processing and undersampling
main_20_multiclass_00.py	Model 1. for Ensembling.
main_21_multiclass_00.py	Model 2. for Ensembling.
main_22_multiclass_00.py	Model 3. for Ensembling.
main_23_multiclass_00.py	Model 4. for Ensembling.
main_24_multiclass_00.py	Model 5. for Ensembling.
main_25_multiclass_00.py	Ensembling results for all models.

3 Result files

The results files are named according to the script which created them.

For instance, `main_00_eda_00_files_list.xlsx` was created by `main_00_eda_00.py`.

They also include the model name for the ConvNet used and the names of the classes to which they pertain.

`main_10_binary_classification_00_Lexus_Mercedes-Benz__model_3model.h5` is a model file for ConvNet Model 3 for the Lexus v. Mercedes-Benz binary classification task, for instance.

Table 3: Types of result files

Result	**File type**
Figures	`*.pdf` or `*.png`
Tables	`*.tex`
Lists	`*.xlsx`
Intermediate numerical results	`*.npy`
Model files	`*.h5` or `*.json`

4 Experiments

4.1 Binary classification task

Table 4: ConvNet models used for the binary classification task

	Model 1	**Model 2**	**Model 3**	**Model 4**
Feature Learning	32conv3x3 + ReLu - mp2x2 32conv3x3 + ReLu - mp2x2 64conv3x3 + ReLu - mp2x2	32conv3x3 + ReLu - mp2x2 64conv3x3 + ReLu - mp2x2 128conv3x3 + ReLu - mp2x2 256conv3x3 + ReLu - mp2x2	32conv3x3 + ReLu - mp2x2 64conv3x3 + ReLu - mp2x2 128conv3x3 + ReLu - mp2x2 128conv3x3 + ReLu - mp2x2	32conv3x3 + ReLu - mp2x2 64conv3x3 + ReLu - mp2x2 128conv3x3 + ReLu - mp2x2 128conv3x3 + ReLu - mp2x2
Classification	flatten fc64 + Relu dropout 0.5 o1 + sigmoid	flatten fc256 + ReLu dropout 0.5 o1 + sigmoid	flatten fc256 + ReLu dropout 0.5 o1 + sigmoid	flatten fc256 + ReLu dropout 0.3 o1 + sigmoid
Reference	main_03_binary_classification_00.py	main_04_binary_classification_00.py	main_05_binary_classification_00.py	main_06_binary_classification_00.py

5 Jupyter notebooks

Jupyter notebooks are in progress.

The first two notebooks are attached to this document.

nb_00_eda_00

April 14, 2020

0.1 ENSC 813 Project

1 Classifying car images in the TCC dataset

1.1 Ashiv Hans Dhondea (301400489)

1.1.1 Spring 2020. Simon Fraser University

1.1.2 Exploratory Data Analysis

This notebook is based on *main_00_eda_00.py* which you can find here.

Creates an excel file listing the names of images employed in this project for reproducibility purposes.

Uses the excel file to select files from the original raw dataset to be included in this project.

[1]:
```
# Import the necessary packages

#  glob and os to navigate directories
#import numpy as np
import xlsxwriter
import glob
import os
import sys
```

All figures (*.png* or *.pdf*), Excel worksheets (*.xlsx*), results tables (*.tex*) created in this project are named according to the script which created them. This is done to avoid confusion and to help future users to reproduce simulation results.

[2]:
```
%%javascript
IPython.notebook.kernel.execute(`notebookName = '${IPython.notebook.
 ↪notebook_name}'`);
```

```
<IPython.core.display.Javascript object>
```

[3]:
```
print(notebookName)
```

```
nb_00_eda_00.ipynb
```

[4]:
```
# Sort out utilities for file naming
# for Jupyter notebook:
# https://stackoverflow.com/questions/52691468/
 ↪can-a-jupyter-notebook-find-its-own-filename
script_name = notebookName[:-6];
full_name = script_name+'_';
print('The full name is %s' %full_name);
# All files created by this script will be named according to this:
```

```
The full name is nb_00_eda_00_
```

[5]:
```
# Explore the directory
path_base = 'TCC_dataset/'
print('Available classes in the dataset are: ');
classes_list = os.listdir(path_base)
print(classes_list);
```

```
Available classes in the dataset are:
['Audi', 'BMW', 'Honda', 'Lexus', 'Mercedes-Benz', 'Toyota']
```

We create an Excel worksheet to save the names of all images in this dataset. This will help us later on when we run ConvNets.

[6]:
```
# Load the dataset
# file type of interest
file_extension = "jpg";

# Create list of file names and store them in an excel worksheet for later
# reference
workbook = xlsxwriter.Workbook(full_name+"files_list.xlsx");

for i in range(0,len(classes_list)):
    worksheet_name = classes_list[i];
    worksheet = workbook.add_worksheet(worksheet_name);
    print('Processing images for class %s' %classes_list[i]);

    # Start from entry 0,0 in worksheet
    row = 0;
    column = 0;

    for file in glob.glob(path_base+"/"+classes_list[i]+"/*."+file_extension):
        index_for_filename = file.index('\\');
        worksheet.write(row, column, file[index_for_filename+1:]);
        row += 1; # Increment to get to next row in worksheet.

workbook.close();
```

```
Processing images for class Audi
Processing images for class BMW
Processing images for class Honda
Processing images for class Lexus
Processing images for class Mercedes-Benz
Processing images for class Toyota
```

[7]:
```python
print('Excel file containing relevant file names has been created.')
```

```
Excel file containing relevant file names has been created.
```

[ ]:
```python

```

nb_02_binary_classification_00

April 14, 2020

0.1 ENSC 813 Project

1 Classifying car images in the TCC dataset

1.1 Ashiv Hans Dhondea (301400489)

1.1.1 Spring 2020. Simon Fraser University

Parameters used:

```
image_dim = dimension of images resized

name_brand_1 = name of first brand of car

name_brand_2 = name of second brand of car
```

[1]:
```
# Select two brands for binary classification. Two of [Audi, BMW, Honda, Lexus,␣
↪Mercedes-Benz, Toyota]
name_brand_1 = 'Honda';
name_brand_2 = 'Toyota';
```

[2]:
```
# Import the necessary packages

# numpy for linear algebra, cv2 for image processing
#  glob and os to navigate directories
import numpy as np
import random
import glob
import os
import sys

# matplotlib for plotting
import matplotlib.pyplot as plt
from matplotlib import rc
rc('font', **{'family': 'serif', 'serif': ['DejaVu Sans']})
rc('text', usetex=True)
params = {'text.latex.preamble' : [r'\usepackage{amsmath}',␣
↪r'\usepackage{amssymb}']}
plt.rcParams.update(params);
```

```
# pandas for excel sheet wrangling
import pandas as pd
#import json

%matplotlib inline
```

[3]:
```
%%javascript
IPython.notebook.kernel.execute(`notebookName = '${IPython.notebook.
↪notebook_name}'`);
```

```
<IPython.core.display.Javascript object>
```

[4]:
```
# Sort out utilities for file naming
# for Jupyter notebook:
# https://stackoverflow.com/questions/52691468/
↪can-a-jupyter-notebook-find-its-own-filename
script_name = notebookName[:-6];

# All files created by this script will be named according to this:
full_name = script_name+'_'+name_brand_1+'_'+name_brand_2+ "_undersampl";
print('The full name is %s' %full_name);
```

```
The full name is nb_02_binary_classification_00_Honda_Toyota_undersampl
```

[5]:
```
path_base = 'TCC_dataset/'
print('Available classes in the dataset are: ');
classes_list = os.listdir(path_base)
print(classes_list);
```

```
Available classes in the dataset are:
['Audi', 'BMW', 'Honda', 'Lexus', 'Mercedes-Benz', 'Toyota']
```

[6]:
```
# file type of interest
file_extension = "jpg";

classes_count = np.zeros([len(classes_list)],dtype=int);

# count how many examples there are for each class
for i in range(len(classes_list)):
    classes_count[i] = len(glob.glob1(path_base + classes_list[i]+"/","*.
↪"+file_extension));

classes_count_total = np.sum(classes_count);
print('Our dataset comprises of %d images.' %classes_count_total);
```

```
# calculate statistics of this dataset
classes_prob = classes_count*(1/np.sum(classes_count));
classes_mean = np.mean(classes_count);
classes_std = np.std(classes_count);

print("The mean number of examples is %.3f \n" %classes_mean);
print("The standard deviation is %.3f examples. \n" %classes_std);
```

```
Our dataset comprises of 7549 images.
The mean number of examples is 1258.167

The standard deviation is 399.019 examples.
```

[7]:
```
# Choose brands for classification
chosen_classes = [name_brand_1,name_brand_2];
print('We will classify images between the following classes:');
print(chosen_classes);

# Count number of examples for each class
chosen_classes_num = np.zeros([len(chosen_classes)],dtype=int);
for i in range(len(chosen_classes)):
    chosen_classes_num[i] = classes_count[classes_list.
 ↪index(chosen_classes[i])];

chosen_classes_total = np.sum(chosen_classes_num);
print('This subset consists of %d images.' %chosen_classes_total);
```

```
We will classify images between the following classes:
['Honda', 'Toyota']
This subset consists of 3059 images.
```

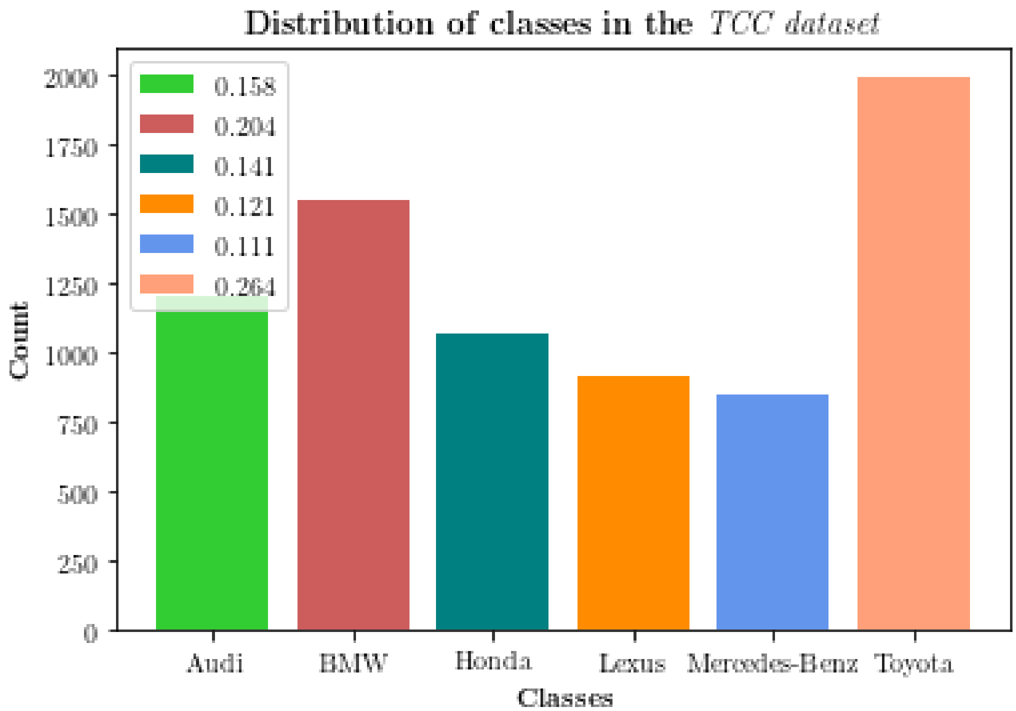
[8]:
```
fig = plt.figure(1);
pos = np.arange(len(classes_list));

color_list =␣
 ↪['limegreen','indianred','teal','darkorange','cornflowerblue','lightsalmon'];

for index in pos:
    plt.bar(index,classes_count[index],color=color_list[index],label=r"%.3f"␣
 ↪%(classes_prob[index]));

plt.xticks(pos,classes_list);
plt.title(r"\textbf{Distribution of classes in the} \textit{TCC␣
 ↪dataset}",fontsize=12)
plt.xlabel(r"\textbf{Classes}")
```

```
plt.ylabel(r"\textbf{Count}")
plt.legend(loc='upper left');
plt.savefig(full_name+'_full_dataset.png');
#plt.savefig(full_name+'full_dataset.pdf');
plt.show();
```



The above bar graph shows that the dataset is unbalanced.

Ideally, we would prefer to have a balanced dataset, that is, each brand should be present 1/6th of the time.

Clearly, some brands, such as *Toyota* with 26.4%, are overrepresented while others are underrepresented, such as *Mercedes-Benz* with 11.1%.

We balance the dataset by undersampling the overrepresented classes.

We randomly choose which particular example from the overrepresented classes will be chosen and which will be excluded from the dataset used for learning.

[9]:
```
# Find the least represented class and undersample the other class
smallest_count_chosen = np.min(chosen_classes_num);
smallest_count_chosen_index = np.argmin(chosen_classes_num);
smallest_count_chosen_id = chosen_classes[smallest_count_chosen_index];
print('The least represented class is %s which has %d examples.'␣
 ↪%(smallest_count_chosen_id,smallest_count_chosen));

print('We will undersample the other class so that we end up with a balanced␣
 ↪dataset')
```

```
The least represented class is Honda which has 1067 examples.
We will undersample the other class so that we end up with a balanced dataset
```

[10]:
```
# Create list of file names for each class to undersample
# Choose randomly in this list to obtain the required number of examples

overall_files_list = [];

for i in range(0,len(chosen_classes)):
    files_list = [];
    for file in glob.glob(path_base+"/"+chosen_classes[i]+"/*."+file_extension):
        index_for_filename = file.index('\\');
        files_list.append(file[index_for_filename+1:]);
    random.shuffle(files_list);
    overall_files_list.extend(files_list[:smallest_count_chosen]);

df_list = pd.DataFrame(overall_files_list);
df_list.to_excel(full_name+'.xlsx', engine='xlsxwriter')
print('Examples per class:')
print(len(overall_files_list)/len(chosen_classes));
```

```
Examples per class:
1067.0
```

We have created an Excel worksheet to save the names of all files which will be used for learning.

We now verify that we created this worksheet correctly.

[11]:
```
# Load excel sheet and verify the distribution of classes
# Read the excel file and pick out the images which are relevant to this script
worksheet_name = 'Sheet1';
list_file = full_name+'.xlsx';
data_frames = pd.read_excel(list_file, sheet_name=worksheet_name);
curated_file_list = np.asarray(data_frames.values.tolist());
```

[12]:
```
curated_file_list_cleaned = [None]*len(curated_file_list);
curated_file_list_classes = [None]*len(curated_file_list);
for k in range(len(curated_file_list)):
    filename = str(curated_file_list[k]);
    curated_file_list_cleaned[k] = filename[2:-2];
    curated_file_list_classes[k] = filename[2:].split("_")[0];

# Find unique classes and their frequencies
curated_brands, curated_brands_freq = np.
↪unique(curated_file_list_classes,return_counts=True);

# Compute stats for the undersampled dataset
curated_brands_prob = np.asarray(curated_brands_freq,dtype=np.float64)*(1/np.
↪sum(np.asarray(curated_brands_freq,dtype=np.float64)));
```

```
curated_brands_mean = np.mean(np.asarray(curated_brands_freq,dtype=np.float64));
curated_brands_std = np.std(np.asarray(curated_brands_freq,dtype=np.float64));

print('For the undersampled dataset:')
print("The mean number of examples is %.3f " %curated_brands_mean);
print("The standard deviation is %.3f examples." %curated_brands_std);
```

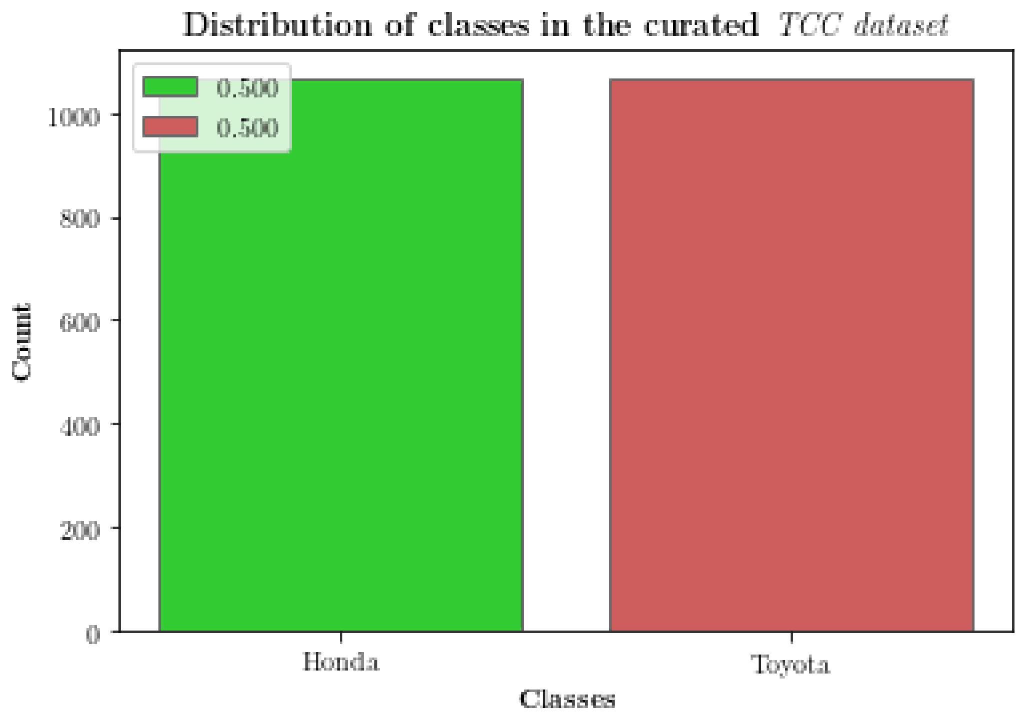
```
For the undersampled dataset:
The mean number of examples is 1067.000
The standard deviation is 0.000 examples.
```

[13]:
```
# Plot the selected dataset (after undersampling)
fig = plt.figure(2);
pos = np.arange(len(curated_brands));

color_list =␣
 ↪['limegreen','indianred','teal','darkorange','cornflowerblue','lightsalmon'];

for index in pos:
    plt.
 ↪bar(index,curated_brands_freq[index],color=color_list[index],edgecolor='dimgray',label=r"%.
 ↪3f" %(curated_brands_prob[index]));

plt.xticks(pos,curated_brands);
plt.title(r"\textbf{Distribution of classes in the curated} \textit{TCC␣
 ↪dataset}",fontsize=12)
plt.xlabel(r"\textbf{Classes}")
plt.ylabel(r"\textbf{Count}")
plt.legend(loc='upper left');
plt.savefig(full_name+'_balanced_dataset.png');
#plt.savefig(full_name+'balanced_dataset.pdf');
plt.show();
```



As can be seen in the above figure, the two brands are equally distributed in the curated dataset.

This helps to avoid issues when working on the learning task.

[ ]: