Project 3

April 6, 2022

Kyle Demers

Project 3

```
[1]: #Import necessary modules
     import pandas as pd
     import numpy as np
     from sklearn.model_selection import KFold
     from sklearn.metrics import accuracy_score, confusion_matrix as CM,
      ↪classification_report
     from sklearn.neighbors import KNeighborsClassifier as KNN
     from sklearn.ensemble import RandomForestClassifier
     from sklearn.preprocessing import StandardScaler, PolynomialFeatures
     from sklearn.svm import SVC
     import seaborn as sns
     import random
     from sklearn.linear_model import LogisticRegression
     from sklearn.preprocessing import LabelEncoder
     from sklearn.model_selection import StratifiedKFold, train_test_split as tts
     from sklearn.metrics import auc, roc_auc_score, roc_curve
     from sklearn.metrics import plot_roc_curve
```

```
[2]: from google.colab import drive
     drive.mount('/content/drive')
```

Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).

```
[3]: !wget https://developer.nvidia.com/compute/cuda/9.0/Prod/local_installers/
      ↪cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb
```

--2022-04-06 00:02:31--
https://developer.nvidia.com/compute/cuda/9.0/Prod/local_installers/cuda-repo-
ubuntu1704-9-0-local_9.0.176-1_amd64-deb
Resolving developer.nvidia.com (developer.nvidia.com)… 152.195.19.142
Connecting to developer.nvidia.com (developer.nvidia.com)|152.195.19.142|:443…
connected.
HTTP request sent, awaiting response… 301 Moved Permanently
Location:

```
https://developer.nvidia.com/compute/cuda/9.0/prod/local_installers/cuda-repo-
ubuntu1704-9-0-local_9.0.176-1_amd64-deb [following]
--2022-04-06 00:02:32--
https://developer.nvidia.com/compute/cuda/9.0/prod/local_installers/cuda-repo-
ubuntu1704-9-0-local_9.0.176-1_amd64-deb
Reusing existing connection to developer.nvidia.com:443.
HTTP request sent, awaiting response… 302 Found
Location: https://developer.download.nvidia.com/compute/cuda/9.0/secure/Prod/loc
al_installers/cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64.deb?UaBAwOUnRsuxA07
-a9xC7HdpQyjNbsOsLEMaCLSNBTUA3ATyvRJA8Fh25sA55SdHqJEAETG71MpvAL4pJjZhHb3dwvZ2UGN
aWFKvzSm0u-kMzUSChPZqkwexLx-Vnpv7aIBv2CsR5cCrwXs3RCNF8OSy4oVEhz5kfqkKoEd18HrFtWt
ea9pzIx7RPpNxeeC1CUFVVyDlO9awpEJ1op6i [following]
--2022-04-06 00:02:32--  https://developer.download.nvidia.com/compute/cuda/9.0/
secure/Prod/local_installers/cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64.deb?
UaBAwOUnRsuxA07-a9xC7HdpQyjNbsOsLEMaCLSNBTUA3ATyvRJA8Fh25sA55SdHqJEAETG71MpvAL4p
JjZhHb3dwvZ2UGNaWFKvzSm0u-kMzUSChPZqkwexLx-Vnpv7aIBv2CsR5cCrwXs3RCNF8OSy4oVEhz5k
fqkKoEd18HrFtWtea9pzIx7RPpNxeeC1CUFVVyDlO9awpEJ1op6i
Resolving developer.download.nvidia.com (developer.download.nvidia.com)…
152.195.19.142
Connecting to developer.download.nvidia.com
(developer.download.nvidia.com)|152.195.19.142|:443… connected.
HTTP request sent, awaiting response… 200 OK
Length: 1216133170 (1.1G) [application/x-deb]
Saving to: 'cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb.1'

cuda-repo-ubuntu170 100%[===================>]   1.13G  68.2MB/s    in 13s

2022-04-06 00:02:45 (89.6 MB/s) - 'cuda-repo-
ubuntu1704-9-0-local_9.0.176-1_amd64-deb.1' saved [1216133170/1216133170]
```

[4]:
```
!ls
```

```
cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb    drive
cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb.1  sample_data
```

[5]:
```
!dpkg -i cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb
!ls /var/cuda-repo-9-0-local | grep .pub
!apt-key add /var/cuda-repo-9-0-local/7fa2af80.pub
!apt-get update
!sudo apt-get install cuda-9.0
```

```
(Reading database … 165522 files and directories currently installed.)
Preparing to unpack cuda-repo-ubuntu1704-9-0-local_9.0.176-1_amd64-deb …
Unpacking cuda-repo-ubuntu1704-9-0-local (9.0.176-1) over (9.0.176-1) …
Setting up cuda-repo-ubuntu1704-9-0-local (9.0.176-1) …
7fa2af80.pub
```

```
OK
Get:1 file:/var/cuda-repo-9-0-local  InRelease
Ign:1 file:/var/cuda-repo-9-0-local  InRelease
Get:2 file:/var/cuda-repo-9-0-local  Release [574 B]
Hit:3 http://security.ubuntu.com/ubuntu bionic-security InRelease
Get:2 file:/var/cuda-repo-9-0-local  Release [574 B]
Hit:4 https://cloud.r-project.org/bin/linux/ubuntu bionic-cran40/ InRelease
Ign:5 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu1804/x86_64
InRelease
Hit:6 http://archive.ubuntu.com/ubuntu bionic InRelease
Hit:7 http://ppa.launchpad.net/c2d4u.team/c2d4u4.0+/ubuntu bionic InRelease
Hit:8 http://archive.ubuntu.com/ubuntu bionic-updates InRelease
Ign:9 https://developer.download.nvidia.com/compute/machine-
learning/repos/ubuntu1804/x86_64  InRelease
Hit:10
https://developer.download.nvidia.com/compute/cuda/repos/ubuntu1804/x86_64
Release
Hit:11 http://archive.ubuntu.com/ubuntu bionic-backports InRelease
Hit:12 https://developer.download.nvidia.com/compute/machine-
learning/repos/ubuntu1804/x86_64  Release
Hit:13 http://ppa.launchpad.net/cran/libgit2/ubuntu bionic InRelease
Hit:15 http://ppa.launchpad.net/deadsnakes/ppa/ubuntu bionic InRelease
Hit:16 http://ppa.launchpad.net/graphics-drivers/ppa/ubuntu bionic InRelease
Reading package lists… Done
Reading package lists… Done
Building dependency tree
Reading state information… Done
Note, selecting 'cuda-9-0' for regex 'cuda-9.0'
Note, selecting 'libcuda-9.0-1' for regex 'cuda-9.0'
cuda-9-0 is already the newest version (9.0.176-1).
0 upgraded, 0 newly installed, 0 to remove and 94 not upgraded.
```

[6]: `!pip install thundersvm`

```
Requirement already satisfied: thundersvm in /usr/local/lib/python3.7/dist-
packages (0.3.12)
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages
(from thundersvm) (1.4.1)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages
(from thundersvm) (1.21.5)
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.7/dist-
packages (from thundersvm) (1.0.2)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-
packages (from scikit-learn->thundersvm) (1.1.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/usr/local/lib/python3.7/dist-packages (from scikit-learn->thundersvm) (3.1.0)
```

```
[7]: from thundersvm import SVC
```

```
[8]: %matplotlib inline
     %config InlineBackend.figure_format = 'retina'
     import matplotlib as mpl
     mpl.rcParams['figure.dpi'] = 150
     import matplotlib.pyplot as plt
     import warnings
     warnings.simplefilter(action='ignore', category=FutureWarning)
```

```
[9]: data = pd.read_csv('/content/drive/MyDrive/Copy of safe_driver_prediction (2).
     ↪csv')
```

```
[ ]: data.tail()
```

```
[ ]:             id  target  ps_ind_01  ps_ind_02_cat  ps_ind_03  ps_ind_04_cat  \
     595207  1488013       0          3              1         10              0
     595208  1488016       0          5              1          3              0
     595209  1488017       0          1              1         10              0
     595210  1488021       0          5              2          3              1
     595211  1488027       0          0              1          8              0

             ps_ind_05_cat  ps_ind_06_bin  ps_ind_07_bin  ps_ind_08_bin  …  \
     595207              0              0              0              0  …
     595208              0              0              0              0  …
     595209              0              1              0              0  …
     595210              0              0              0              1  …
     595211              0              1              0              0  …

             ps_calc_11  ps_calc_12  ps_calc_13  ps_calc_14  ps_calc_15_bin  \
     595207           4           1           9           6               0
     595208           4           1           3           8               1
     595209           3           2           2           6               0
     595210           4           1           4           2               0
     595211           4           4           3           8               0

             ps_calc_16_bin  ps_calc_17_bin  ps_calc_18_bin  ps_calc_19_bin  \
     595207               1               1               0               1
     595208               0               1               0               1
     595209               0               1               0               0
     595210               1               1               1               0
     595211               1               0               0               0

             ps_calc_20_bin
     595207               1
     595208               1
     595209               0
```

```
595210          0
595211          0
```

```
[5 rows x 59 columns]
```

[ ]: `data.shape`

[ ]: (595212, 59)

[ ]: `np.unique(data['target'])`

[ ]: `array([0, 1])`

[ ]:
```python
#no Nans
data.isnull().sum().sum()
```

[ ]: 0

[10]:
```python
y = data['target'].values
x = data.loc[:,'ps_ind_01':'ps_calc_20_bin'].values
```

[11]:
```python
scaler = StandardScaler()
xs = scaler.fit_transform(x)
```

Create a smaller data set to use for testing code with

[39]:
```python
#k was 10,000 but was changed to run full dataset.
idxs = np.arange(0,595211)
idxs = random.choices(idxs, k = 350000)
smalldata = data.iloc[idxs]
x1 = smalldata.loc[:,'ps_ind_01':'ps_calc_20_bin'].values
y1 = smalldata['target'].values
xs1 = scaler.fit_transform(x1)
```

Important conclusion that weights need to be set:

[ ]:
```python
kf = KFold(n_splits=10,shuffle=True)
accuracy = []
model = LogisticRegression(solver='lbfgs',max_iter=500000)

for idxtrain, idxtest in kf.split(x):
    xtrain = x[idxtrain]
    xtest = x[idxtest]
    ytrain = y[idxtrain]
    ytest = y[idxtest]
    model.fit(xtrain,ytrain)
    predicted_classes = model.predict(xtest)
    accuracy.append(accuracy_score(ytest,predicted_classes))
```

```
    print('done')
print(np.mean(accuracy))
```

```
done
done
done
done
done
done
done
done
done
done
0.9635524802536614
```

`[ ]:` `(0 + sum(y ==0))/len(y)`

`[ ]:` 0.963552482140817

notice that this is the same score. We have a class imbalance as the model predicts always targets as 1 which optimizes its score.

Classification using Logistic Regression:

```
[40]: avgPrecision = []
avgRecall = []
# Classification and ROC analysis

# Run classifier with cross-validation and plot ROC curves
cv = StratifiedKFold(n_splits=10,shuffle = True)
#We have a class imbalance so class_weight perameter needs to be balanced
classifier =␣
 ↪LogisticRegression(solver='lbfgs',max_iter=100000,class_weight='balanced')

tprs = []
aucs = []
mean_fpr = np.linspace(0, 1, 100)

fig, ax = plt.subplots(figsize=(10,8))
for i, (train, test) in enumerate(cv.split(x, y)):
    classifier.fit(x[train], y[train])
    viz = plot_roc_curve(classifier, x[test], y[test],
                         name='ROC fold {}'.format(i),
                         alpha=0.3, lw=1, ax=ax)
    interp_tpr = np.interp(mean_fpr, viz.fpr, viz.tpr)
    interp_tpr[0] = 0.0
    tprs.append(interp_tpr)
    aucs.append(viz.roc_auc)
```

```
    report = classification_report(y[test],classifier.
 →predict(x[test]),output_dict=True)
    avgPrecision.append(report['1']['precision'])
    avgRecall.append(report['1']['recall'])
    #counter
    print('finished running KFold ' + str(i))
print('the average precision across 10 KFolds is: ' + str(np.
 →mean(avgPrecision)) + ' and the average recall is: ' + str(np.
 →mean(avgRecall)) + 'using a Logistic Regression.')
#plot
ax.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r',
        label='Chance', alpha=.8)

mean_tpr = np.mean(tprs, axis=0)
mean_tpr[-1] = 1.0
std_auc = np.std(aucs)
ax.plot(mean_fpr, mean_tpr, color='b',
        lw=2, alpha=.8)

std_tpr = np.std(tprs, axis=0)
tprs_upper = np.minimum(mean_tpr + std_tpr, 1)
tprs_lower = np.maximum(mean_tpr - std_tpr, 0)
ax.fill_between(mean_fpr, tprs_lower, tprs_upper, color='grey', alpha=.2,
                label=r'$\pm$ 1 std. dev.')

ax.set(xlim=[-0.05, 1.05], ylim=[-0.05, 1.05],
        title="Classification method: Linear Regression")
ax.legend(loc="lower right")
plt.show()
```
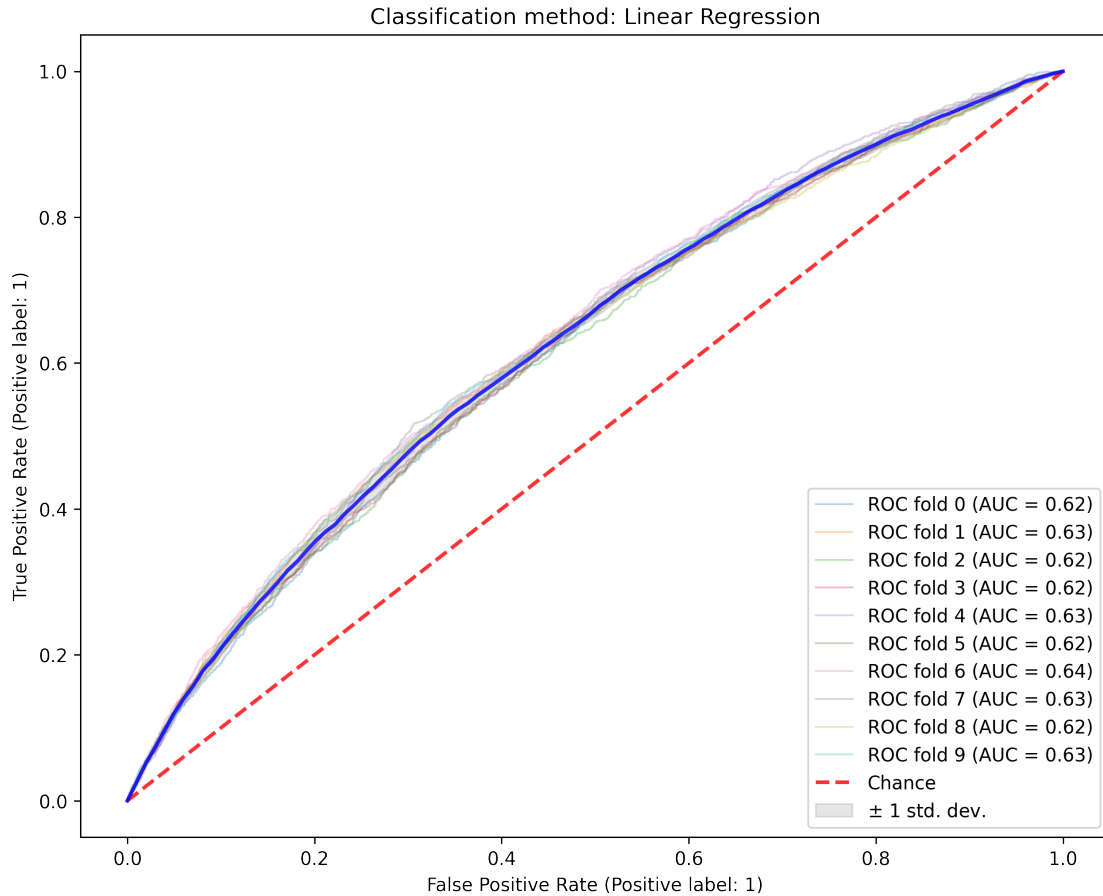
```
finished running KFold 0
finished running KFold 1
finished running KFold 2
finished running KFold 3
finished running KFold 4
finished running KFold 5
finished running KFold 6
finished running KFold 7
finished running KFold 8
finished running KFold 9
the average precision across 10 KFolds is: 0.05341025971111679 and the average
recall is: 0.5532784401876466using a Logistic Regression.
```

Classification method: Linear Regression

Analysis: The model is very loose on classifying class 1s. Of all the people that the model classified as class 1s, only 5% were class 1s. However, out of all the class 1s in the data set, 55% were correctly classified.

Classification using Random Forest:

```
[30]: avgPrecision = []
      avgRecall = []
      # Classification and ROC analysis

      # Run classifier with cross-validation and plot ROC curves
      cv = StratifiedKFold(n_splits=10,shuffle = True)
      #We have a class imbalance so class_weight perameter needs to be balanced
      classifier = RandomForestClassifier(n_estimators = 100, max_depth = 10,␣
       ↪class_weight='balanced')

      tprs = []
      aucs = []
      mean_fpr = np.linspace(0, 1, 100)
```

```
fig, ax = plt.subplots(figsize=(10,8))
for i, (train, test) in enumerate(cv.split(x, y)):
    classifier.fit(x[train], y[train])
    viz = plot_roc_curve(classifier, x[test], y[test],
                         name='ROC fold {}'.format(i),
                         alpha=0.3, lw=1, ax=ax)
    interp_tpr = np.interp(mean_fpr, viz.fpr, viz.tpr)
    interp_tpr[0] = 0.0
    tprs.append(interp_tpr)
    aucs.append(viz.roc_auc)
    report = classification_report(y[test],classifier.
 ↪predict(x[test]),output_dict=True)
    avgPrecision.append(report['1']['precision'])
    avgRecall.append(report['1']['recall'])
    #counter
    print('finished running KFold ' + str(i))
print('the average precision across 10 KFolds is: ' + str(np.
 ↪mean(avgPrecision)) + ' and the average recall is: ' + str(np.
 ↪mean(avgRecall)) + 'using a Random Forest Classifier with a max depth of 10.
 ↪')
#plot
ax.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r',
        label='Chance', alpha=.8)

mean_tpr = np.mean(tprs, axis=0)
mean_tpr[-1] = 1.0
std_auc = np.std(aucs)
ax.plot(mean_fpr, mean_tpr, color='b',
        lw=2, alpha=.8)

std_tpr = np.std(tprs, axis=0)
tprs_upper = np.minimum(mean_tpr + std_tpr, 1)
tprs_lower = np.maximum(mean_tpr - std_tpr, 0)
ax.fill_between(mean_fpr, tprs_lower, tprs_upper, color='grey', alpha=.2,
                label=r'$\pm$ 1 std. dev.')

ax.set(xlim=[-0.05, 1.05], ylim=[-0.05, 1.05],
       title="Classification Method: Random Forest")
ax.legend(loc="lower right")
plt.show()
```
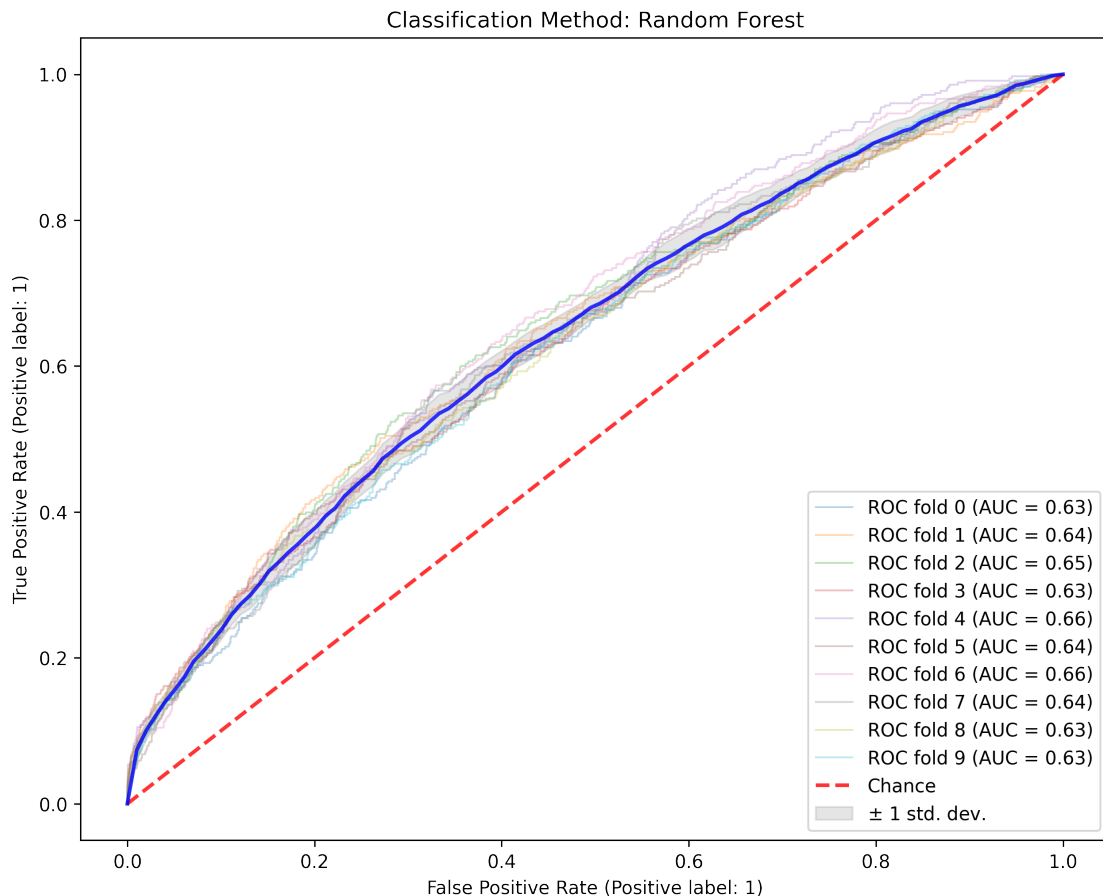
```
finished running KFold 0
finished running KFold 1
finished running KFold 2
finished running KFold 3
finished running KFold 4
```

```
finished running KFold 5
finished running KFold 6
finished running KFold 7
finished running KFold 8
finished running KFold 9
the average precision across 10 KFolds is: 0.09540420022012747 and the average
recall is: 0.17288855812166898using a Random Forest Classifier with a max depth
of 10.
```


Classification Method: Random Forest

Analysis: The Random Forest model performs very poorly in general. Of all the people that the model classified as class 1s, only 9% were class 1s. However, out of all the class 1s in the data set, 17% were correctly classified.

Classification Using KNN

[32]:
```
avgPrecision = []
avgRecall = []
# Classification and ROC analysis

# Run classifier with cross-validation and plot ROC curves
```

```python
cv = StratifiedKFold(n_splits=10,shuffle = True)
classifier = KNN(n_neighbors=5,weights='distance')

tprs = []
aucs = []
mean_fpr = np.linspace(0, 1, 100)

fig, ax = plt.subplots(figsize=(10,8))
for i, (train, test) in enumerate(cv.split(x, y)):
    classifier.fit(x[train], y[train])
    viz = plot_roc_curve(classifier, x[test], y[test],
                         name='ROC fold {}'.format(i),
                         alpha=0.3, lw=1, ax=ax)
    interp_tpr = np.interp(mean_fpr, viz.fpr, viz.tpr)
    interp_tpr[0] = 0.0
    tprs.append(interp_tpr)
    aucs.append(viz.roc_auc)
    report = classification_report(y[test],classifier.
 ↪predict(x[test]),output_dict=True)
    avgPrecision.append(report['1']['precision'])
    avgRecall.append(report['1']['recall'])
    #counter
    print('finished running KFold ' + str(i))
print('the average precision across 10 KFolds is: ' + str(np.
 ↪mean(avgPrecision)) + ' and the average recall is: ' + str(np.
 ↪mean(avgRecall)) + 'using a KNN with weights set to distance')
#Plot
ax.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r',
        label='Chance', alpha=.8)

mean_tpr = np.mean(tprs, axis=0)
mean_tpr[-1] = 1.0
std_auc = np.std(aucs)
ax.plot(mean_fpr, mean_tpr, color='b',
        lw=2, alpha=.8)

std_tpr = np.std(tprs, axis=0)
tprs_upper = np.minimum(mean_tpr + std_tpr, 1)
tprs_lower = np.maximum(mean_tpr - std_tpr, 0)
ax.fill_between(mean_fpr, tprs_lower, tprs_upper, color='grey', alpha=.2,
                label=r'$\pm$ 1 std. dev.')

ax.set(xlim=[-0.05, 1.05], ylim=[-0.05, 1.05],
       title="Classification Method: KNN")
ax.legend(loc="lower right")
plt.show()
```
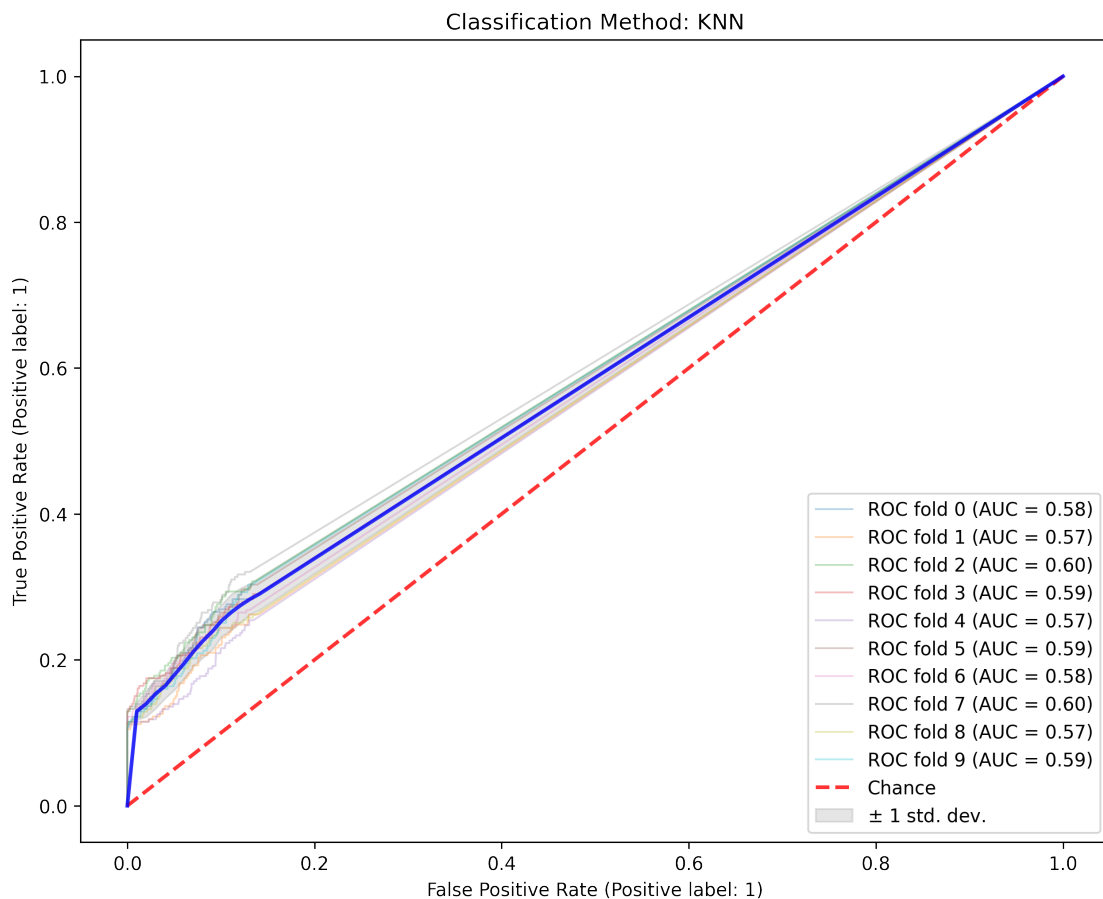
```
finished running KFold 0
finished running KFold 1
finished running KFold 2
finished running KFold 3
finished running KFold 4
finished running KFold 5
finished running KFold 6
finished running KFold 7
finished running KFold 8
finished running KFold 9
```
the average precision across 10 KFolds is: 0.7611394832316497 and the average recall is: 0.1179369411076728using a KNN with weights set to distance

Analysis: The KNN modelis very strict on selecting class 1s. Of all the people that the model classified as class 1s, 76% were class 1s. However, out of all the class 1s in the data set, only 11% were correctly classified.

Classification model using Thunder SVM

```
[18]:  avgPrecision = []
       avgRecall = []
       # Classification and ROC analysis

       # Run classifier with cross-validation and plot ROC curves
       cv = StratifiedKFold(n_splits=10,shuffle = True)
       classifier = SVC(kernel='rbf',C=1, gamma=0.1,probability=True)

       tprs = []
       aucs = []
       mean_fpr = np.linspace(0, 1, 100)

       fig, ax = plt.subplots(figsize=(10,8))
       for i, (train, test) in enumerate(cv.split(x, y)):
           classifier.fit(x[train], y[train])
           report = classification_report(y[test],classifier.
        ↪predict(x[test]),output_dict=True)
           avgPrecision.append(report['1']['precision'])
           avgRecall.append(report['1']['recall'])
           y_pred_proba = classifier.predict_proba(x)[::,1]
           fpr,tpr, _ = roc_curve(y,y_pred_proba)
           auc = roc_auc_score(y, y_pred_proba)
           #plot the line
           plt.plot(fpr,tpr,label="AUC="+str(auc) + ' for fold ' + str(i))
           #counter
           print('finished running KFold ' + str(i))
       print('the average precision across 10 KFolds is: ' + str(np.
        ↪mean(avgPrecision)) + ' and the average recall is: ' + str(np.
        ↪mean(avgRecall)) + ' using Thunder SVM.')
       #make plot pretty
       ax.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r',
               label='Chance', alpha=.8)
       plt.legend(loc=4)
       plt.ylabel('True Positive Rate')
       plt.xlabel('False Positive Rate')
       ax.set(xlim=[-0.05, 1.05], ylim=[-0.05, 1.05],
               title="Classification Method: Thunder SVM")

       plt.show()
```
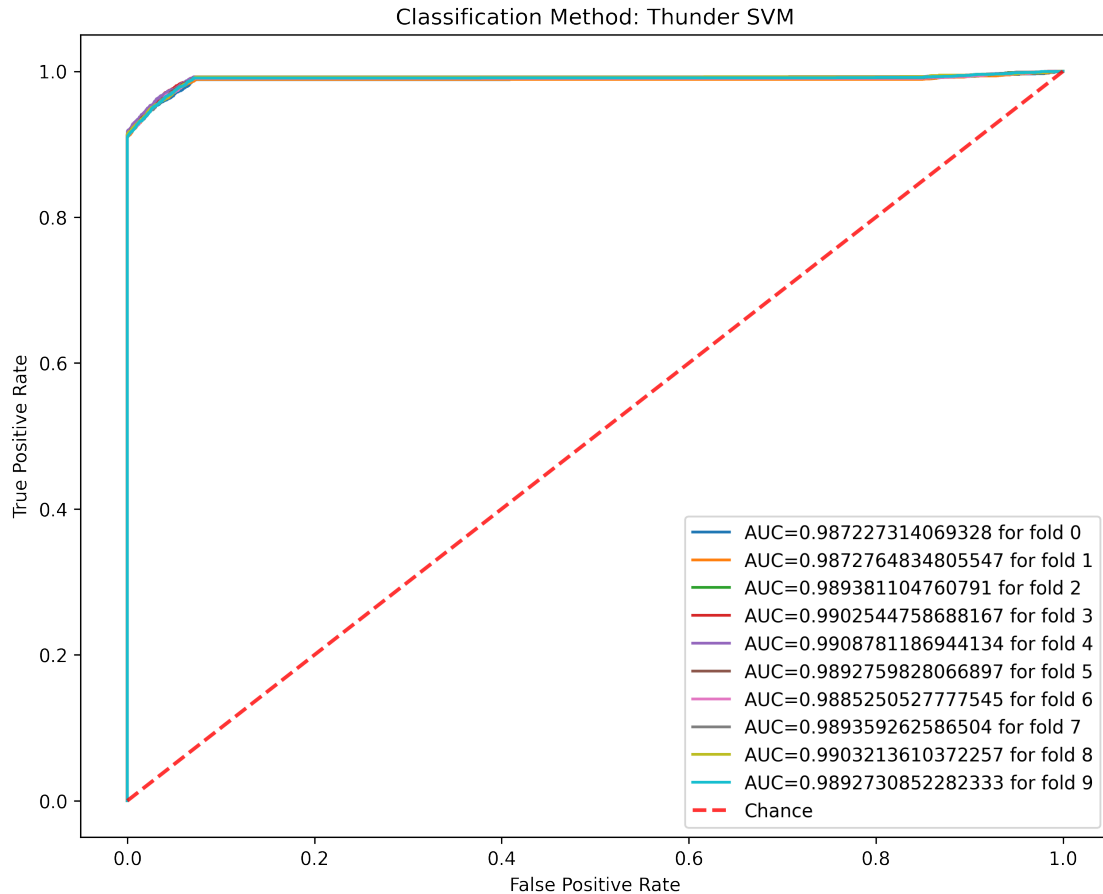
```
finished running KFold 0
finished running KFold 1
finished running KFold 2
finished running KFold 3
finished running KFold 4
finished running KFold 5
finished running KFold 6
```

```
finished running KFold 7
finished running KFold 8
finished running KFold 9
the average precision across 10 KFolds is: 1.0 and the average recall is:
0.12680284741566078 using Thunder SVM.
```


Classification Method: Thunder SVM

Analysis: The KNN model is very strict on selecting class 1s. Of all the people that the model classified as class 1s, 100% were class 1s. This means there wasn't a single false positive. However, out of all the class 1s in the data set, only 13% were correctly classified. This means there were many false negatives.

1 Conclusion:

There is a strong trade off between getting a good precision score and a good Recall score. If you're willing to get more class 1s correctly classified at the cost of misclassifying many class 0s, then a logistic regression would be best. When trying to make sure that the people classified as class 1s are only class 1s, then an SVC works best. If you want a mix of both(with very subpar results) then a Random forest may be the best choice, however this trade off is a small increase in recall

for a massive decrease in precision. In terms of the dataset I would pick the SVC because if it can correctly identify some people who will file an insurance claim, then they can be charged higher rates. This doesn't get everyone to who file a claim, but considering the high false positive rate of the other models, this seems the most fair.

```
[ ]:  !apt-get install texlive texlive-xetex texlive-latex-extra pandoc

      !pip install pypandoc
```

```
Reading package lists… Done
Building dependency tree
Reading state information… Done
pandoc is already the newest version (1.19.2.4~dfsg-1build4).
pandoc set to manually installed.
The following additional packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
  libruby2.5 libsynctex1 libtexlua52 libtexluajit2 libzzip-0-13 lmodern
  poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
  ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
  rubygems-integration t1utils tex-common tex-gyre texlive-base
  texlive-binaries texlive-fonts-recommended texlive-latex-base
  texlive-latex-recommended texlive-pictures texlive-plain-generic tipa
Suggested packages:
  fonts-noto apache2 | lighttpd | httpd poppler-utils ghostscript
  fonts-japanese-mincho | fonts-ipafont-mincho fonts-japanese-gothic
  | fonts-ipafont-gothic fonts-arphic-ukai fonts-arphic-uming fonts-nanum ri
  ruby-dev bundler debhelper gv | postscript-viewer perl-tk xpdf-reader
  | pdf-viewer texlive-fonts-recommended-doc texlive-latex-base-doc
  python-pygments icc-profiles libfile-which-perl
  libspreadsheet-parseexcel-perl texlive-latex-extra-doc
  texlive-latex-recommended-doc texlive-pstricks dot2tex prerex ruby-tcltk
  | libtcltk-ruby texlive-pictures-doc vprerex
The following NEW packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
  libruby2.5 libsynctex1 libtexlua52 libtexluajit2 libzzip-0-13 lmodern
  poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
  ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
  rubygems-integration t1utils tex-common tex-gyre texlive texlive-base
  texlive-binaries texlive-fonts-recommended texlive-latex-base
  texlive-latex-extra texlive-latex-recommended texlive-pictures
  texlive-plain-generic texlive-xetex tipa
0 upgraded, 47 newly installed, 0 to remove and 94 not upgraded.
Need to get 146 MB of archives.
After this operation, 460 MB of additional disk space will be used.
```

```
Get:1 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-droid-fallback
all 1:6.0.1r16-1.1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lato all 2.0-2
[2,698 kB]
Get:3 http://archive.ubuntu.com/ubuntu bionic/main amd64 poppler-data all
0.4.8-2 [1,479 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic/main amd64 tex-common all 6.09
[33.0 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lmodern all
2.004.5-3 [4,551 kB]
Get:6 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-noto-mono all
20171026-2 [75.5 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic/universe amd64 fonts-texgyre all
20160520-1 [8,761 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic/main amd64 javascript-common all
11 [6,066 B]
Get:9 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsfilters1
amd64 1.20.2-0ubuntu3.1 [108 kB]
Get:10 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsimage2
amd64 2.2.7-1ubuntu2.8 [18.6 kB]
Get:11 http://archive.ubuntu.com/ubuntu bionic/main amd64 libijs-0.35 amd64
0.35-13 [15.5 kB]
Get:12 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjbig2dec0 amd64
0.13-6 [55.9 kB]
Get:13 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9-common
all 9.26~dfsg+0-0ubuntu0.18.04.15 [5,092 kB]
Get:14 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9 amd64
9.26~dfsg+0-0ubuntu0.18.04.15 [2,265 kB]
Get:15 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjs-jquery all
3.2.1-1 [152 kB]
Get:16 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libkpathsea6
amd64 2017.20170613.44572-8ubuntu0.1 [54.9 kB]
Get:17 http://archive.ubuntu.com/ubuntu bionic/main amd64 libpotrace0 amd64
1.14-2 [17.4 kB]
Get:18 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libptexenc1
amd64 2017.20170613.44572-8ubuntu0.1 [34.5 kB]
Get:19 http://archive.ubuntu.com/ubuntu bionic/main amd64 rubygems-integration
all 1.11 [4,994 B]
Get:20 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 ruby2.5 amd64
2.5.1-1ubuntu1.11 [48.6 kB]
Get:21 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby amd64 1:2.5.1
[5,712 B]
Get:22 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 rake all
12.3.1-1ubuntu0.1 [44.9 kB]
Get:23 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-did-you-mean all
1.2.0-2 [9,700 B]
Get:24 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-minitest all
5.10.3-1 [38.6 kB]
```

```
Get:25 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-net-telnet all
0.1.1-2 [12.6 kB]
Get:26 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-power-assert all
0.3.0-1 [7,952 B]
Get:27 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-test-unit all
3.2.5-1 [61.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libruby2.5
amd64 2.5.1-1ubuntu1.11 [3,072 kB]
Get:29 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libsynctex1
amd64 2017.20170613.44572-8ubuntu0.1 [41.4 kB]
Get:30 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libtexlua52
amd64 2017.20170613.44572-8ubuntu0.1 [91.2 kB]
Get:31 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libtexluajit2
amd64 2017.20170613.44572-8ubuntu0.1 [230 kB]
Get:32 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libzzip-0-13
amd64 0.13.62-3.1ubuntu0.18.04.1 [26.0 kB]
Get:33 http://archive.ubuntu.com/ubuntu bionic/main amd64 lmodern all 2.004.5-3
[9,631 kB]
Get:34 http://archive.ubuntu.com/ubuntu bionic/main amd64 preview-latex-style
all 11.91-1ubuntu1 [185 kB]
Get:35 http://archive.ubuntu.com/ubuntu bionic/main amd64 t1utils amd64 1.41-2
[56.0 kB]
Get:36 http://archive.ubuntu.com/ubuntu bionic/universe amd64 tex-gyre all
20160520-1 [4,998 kB]
Get:37 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 texlive-
binaries amd64 2017.20170613.44572-8ubuntu0.1 [8,179 kB]
Get:38 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-base all
2017.20180305-1 [18.7 MB]
Get:39 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-fonts-
recommended all 2017.20180305-1 [5,262 kB]
Get:40 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-latex-base all
2017.20180305-1 [951 kB]
Get:41 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-latex-
recommended all 2017.20180305-1 [14.9 MB]
Get:42 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive all
2017.20180305-1 [14.4 kB]
Get:43 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-pictures
all 2017.20180305-1 [4,026 kB]
Get:44 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-latex-
extra all 2017.20180305-2 [10.6 MB]
Get:45 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-plain-
generic all 2017.20180305-2 [23.6 MB]
Get:46 http://archive.ubuntu.com/ubuntu bionic/universe amd64 tipa all 2:1.3-20
[2,978 kB]
Get:47 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-xetex all
2017.20180305-1 [10.7 MB]
Fetched 146 MB in 6s (22.6 MB/s)
Extracting templates from packages: 100%
```

```
Preconfiguring packages …
Selecting previously unselected package fonts-droid-fallback.
(Reading database … 165522 files and directories currently installed.)
Preparing to unpack …/00-fonts-droid-fallback_1%3a6.0.1r16-1.1_all.deb …
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1) …
Selecting previously unselected package fonts-lato.
Preparing to unpack …/01-fonts-lato_2.0-2_all.deb …
Unpacking fonts-lato (2.0-2) …
Selecting previously unselected package poppler-data.
Preparing to unpack …/02-poppler-data_0.4.8-2_all.deb …
Unpacking poppler-data (0.4.8-2) …
Selecting previously unselected package tex-common.
Preparing to unpack …/03-tex-common_6.09_all.deb …
Unpacking tex-common (6.09) …
Selecting previously unselected package fonts-lmodern.
Preparing to unpack …/04-fonts-lmodern_2.004.5-3_all.deb …
Unpacking fonts-lmodern (2.004.5-3) …
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack …/05-fonts-noto-mono_20171026-2_all.deb …
Unpacking fonts-noto-mono (20171026-2) …
Selecting previously unselected package fonts-texgyre.
Preparing to unpack …/06-fonts-texgyre_20160520-1_all.deb …
Unpacking fonts-texgyre (20160520-1) …
Selecting previously unselected package javascript-common.
Preparing to unpack …/07-javascript-common_11_all.deb …
Unpacking javascript-common (11) …
Selecting previously unselected package libcupsfilters1:amd64.
Preparing to unpack …/08-libcupsfilters1_1.20.2-0ubuntu3.1_amd64.deb …
Unpacking libcupsfilters1:amd64 (1.20.2-0ubuntu3.1) …
Selecting previously unselected package libcupsimage2:amd64.
Preparing to unpack …/09-libcupsimage2_2.2.7-1ubuntu2.8_amd64.deb …
Unpacking libcupsimage2:amd64 (2.2.7-1ubuntu2.8) …
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack …/10-libijs-0.35_0.35-13_amd64.deb …
Unpacking libijs-0.35:amd64 (0.35-13) …
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack …/11-libjbig2dec0_0.13-6_amd64.deb …
Unpacking libjbig2dec0:amd64 (0.13-6) …
Selecting previously unselected package libgs9-common.
Preparing to unpack …/12-libgs9-common_9.26~dfsg+0-0ubuntu0.18.04.15_all.deb
…
Unpacking libgs9-common (9.26~dfsg+0-0ubuntu0.18.04.15) …
Selecting previously unselected package libgs9:amd64.
Preparing to unpack …/13-libgs9_9.26~dfsg+0-0ubuntu0.18.04.15_amd64.deb …
Unpacking libgs9:amd64 (9.26~dfsg+0-0ubuntu0.18.04.15) …
Selecting previously unselected package libjs-jquery.
Preparing to unpack …/14-libjs-jquery_3.2.1-1_all.deb …
Unpacking libjs-jquery (3.2.1-1) …
```

```
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack …/15-libkpathsea6_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libkpathsea6:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libpotrace0.
Preparing to unpack …/16-libpotrace0_1.14-2_amd64.deb …
Unpacking libpotrace0 (1.14-2) …
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack …/17-libptexenc1_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libptexenc1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package rubygems-integration.
Preparing to unpack …/18-rubygems-integration_1.11_all.deb …
Unpacking rubygems-integration (1.11) …
Selecting previously unselected package ruby2.5.
Preparing to unpack …/19-ruby2.5_2.5.1-1ubuntu1.11_amd64.deb …
Unpacking ruby2.5 (2.5.1-1ubuntu1.11) …
Selecting previously unselected package ruby.
Preparing to unpack …/20-ruby_1%3a2.5.1_amd64.deb …
Unpacking ruby (1:2.5.1) …
Selecting previously unselected package rake.
Preparing to unpack …/21-rake_12.3.1-1ubuntu0.1_all.deb …
Unpacking rake (12.3.1-1ubuntu0.1) …
Selecting previously unselected package ruby-did-you-mean.
Preparing to unpack …/22-ruby-did-you-mean_1.2.0-2_all.deb …
Unpacking ruby-did-you-mean (1.2.0-2) …
Selecting previously unselected package ruby-minitest.
Preparing to unpack …/23-ruby-minitest_5.10.3-1_all.deb …
Unpacking ruby-minitest (5.10.3-1) …
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack …/24-ruby-net-telnet_0.1.1-2_all.deb …
Unpacking ruby-net-telnet (0.1.1-2) …
Selecting previously unselected package ruby-power-assert.
Preparing to unpack …/25-ruby-power-assert_0.3.0-1_all.deb …
Unpacking ruby-power-assert (0.3.0-1) …
Selecting previously unselected package ruby-test-unit.
Preparing to unpack …/26-ruby-test-unit_3.2.5-1_all.deb …
Unpacking ruby-test-unit (3.2.5-1) …
Selecting previously unselected package libruby2.5:amd64.
Preparing to unpack …/27-libruby2.5_2.5.1-1ubuntu1.11_amd64.deb …
Unpacking libruby2.5:amd64 (2.5.1-1ubuntu1.11) …
Selecting previously unselected package libsynctex1:amd64.
Preparing to unpack …/28-libsynctex1_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libsynctex1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libtexlua52:amd64.
Preparing to unpack …/29-libtexlua52_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
```

```
Unpacking libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
…/30-libtexluajit2_2017.20170613.44572-8ubuntu0.1_amd64.deb …
Unpacking libtexluajit2:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libzzip-0-13:amd64.
Preparing to unpack …/31-libzzip-0-13_0.13.62-3.1ubuntu0.18.04.1_amd64.deb …
Unpacking libzzip-0-13:amd64 (0.13.62-3.1ubuntu0.18.04.1) …
Selecting previously unselected package lmodern.
Preparing to unpack …/32-lmodern_2.004.5-3_all.deb …
Unpacking lmodern (2.004.5-3) …
Selecting previously unselected package preview-latex-style.
Preparing to unpack …/33-preview-latex-style_11.91-1ubuntu1_all.deb …
Unpacking preview-latex-style (11.91-1ubuntu1) …
Selecting previously unselected package t1utils.
Preparing to unpack …/34-t1utils_1.41-2_amd64.deb …
Unpacking t1utils (1.41-2) …
Selecting previously unselected package tex-gyre.
Preparing to unpack …/35-tex-gyre_20160520-1_all.deb …
Unpacking tex-gyre (20160520-1) …
Selecting previously unselected package texlive-binaries.
Preparing to unpack …/36-texlive-
binaries_2017.20170613.44572-8ubuntu0.1_amd64.deb …
Unpacking texlive-binaries (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package texlive-base.
Preparing to unpack …/37-texlive-base_2017.20180305-1_all.deb …
Unpacking texlive-base (2017.20180305-1) …
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack …/38-texlive-fonts-recommended_2017.20180305-1_all.deb …
Unpacking texlive-fonts-recommended (2017.20180305-1) …
Selecting previously unselected package texlive-latex-base.
Preparing to unpack …/39-texlive-latex-base_2017.20180305-1_all.deb …
Unpacking texlive-latex-base (2017.20180305-1) …
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack …/40-texlive-latex-recommended_2017.20180305-1_all.deb …
Unpacking texlive-latex-recommended (2017.20180305-1) …
Selecting previously unselected package texlive.
Preparing to unpack …/41-texlive_2017.20180305-1_all.deb …
Unpacking texlive (2017.20180305-1) …
Selecting previously unselected package texlive-pictures.
Preparing to unpack …/42-texlive-pictures_2017.20180305-1_all.deb …
Unpacking texlive-pictures (2017.20180305-1) …
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack …/43-texlive-latex-extra_2017.20180305-2_all.deb …
Unpacking texlive-latex-extra (2017.20180305-2) …
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack …/44-texlive-plain-generic_2017.20180305-2_all.deb …
Unpacking texlive-plain-generic (2017.20180305-2) …
```

```
Selecting previously unselected package tipa.
Preparing to unpack …/45-tipa_2%3a1.3-20_all.deb …
Unpacking tipa (2:1.3-20) …
Selecting previously unselected package texlive-xetex.
Preparing to unpack …/46-texlive-xetex_2017.20180305-1_all.deb …
Unpacking texlive-xetex (2017.20180305-1) …
Setting up libgs9-common (9.26~dfsg+0-0ubuntu0.18.04.15) …
Setting up libkpathsea6:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up libjs-jquery (3.2.1-1) …
Setting up libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up fonts-droid-fallback (1:6.0.1r16-1.1) …
Setting up libsynctex1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up libptexenc1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up tex-common (6.09) …
update-language: texlive-base not installed and configured, doing nothing!
Setting up poppler-data (0.4.8-2) …
Setting up tex-gyre (20160520-1) …
Setting up preview-latex-style (11.91-1ubuntu1) …
Setting up fonts-texgyre (20160520-1) …
Setting up fonts-noto-mono (20171026-2) …
Setting up fonts-lato (2.0-2) …
Setting up libcupsfilters1:amd64 (1.20.2-0ubuntu3.1) …
Setting up libcupsimage2:amd64 (2.2.7-1ubuntu2.8) …
Setting up libjbig2dec0:amd64 (0.13-6) …
Setting up ruby-did-you-mean (1.2.0-2) …
Setting up t1utils (1.41-2) …
Setting up ruby-net-telnet (0.1.1-2) …
Setting up libijs-0.35:amd64 (0.35-13) …
Setting up rubygems-integration (1.11) …
Setting up libpotrace0 (1.14-2) …
Setting up javascript-common (11) …
Setting up ruby-minitest (5.10.3-1) …
Setting up libzzip-0-13:amd64 (0.13.62-3.1ubuntu0.18.04.1) …
Setting up libgs9:amd64 (9.26~dfsg+0-0ubuntu0.18.04.15) …
Setting up libtexluajit2:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up fonts-lmodern (2.004.5-3) …
Setting up ruby-power-assert (0.3.0-1) …
Setting up texlive-binaries (2017.20170613.44572-8ubuntu0.1) …
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
(bibtex) in auto mode
Setting up texlive-base (2017.20180305-1) …
mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST…
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN…
mktexlsr: Updating /var/lib/texmf/ls-R…
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
```

```
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4:
/var/lib/texmf/tex/generic/config/pdftexconfig.tex
Setting up texlive-fonts-recommended (2017.20180305-1) …
Setting up texlive-plain-generic (2017.20180305-2) …
Setting up texlive-latex-base (2017.20180305-1) …
Setting up lmodern (2.004.5-3) …
Setting up texlive-latex-recommended (2017.20180305-1) …
Setting up texlive-pictures (2017.20180305-1) …
Setting up tipa (2:1.3-20) …
Regenerating '/var/lib/texmf/fmtutil.cnf-DEBIAN'… done.
Regenerating '/var/lib/texmf/fmtutil.cnf-TEXLIVEDIST'… done.
update-fmtutil has updated the following file(s):
        /var/lib/texmf/fmtutil.cnf-DEBIAN
        /var/lib/texmf/fmtutil.cnf-TEXLIVEDIST
If you want to activate the changes in the above file(s),
you should run fmtutil-sys or fmtutil.
Setting up texlive (2017.20180305-1) …
Setting up texlive-latex-extra (2017.20180305-2) …
Setting up texlive-xetex (2017.20180305-1) …
Setting up ruby2.5 (2.5.1-1ubuntu1.11) …
Setting up ruby (1:2.5.1) …
Setting up ruby-test-unit (3.2.5-1) …
Setting up rake (12.3.1-1ubuntu0.1) …
Setting up libruby2.5:amd64 (2.5.1-1ubuntu1.11) …
Processing triggers for mime-support (3.60ubuntu1) …
Processing triggers for libc-bin (2.27-3ubuntu1.3) …
/sbin/ldconfig.real: /usr/local/lib/python3.7/dist-
packages/ideep4py/lib/libmkldnn.so.0 is not a symbolic link

Processing triggers for man-db (2.8.3-2ubuntu0.1) …
Processing triggers for fontconfig (2.12.6-0ubuntu2) …
Processing triggers for tex-common (6.09) …
Running updmap-sys. This may take some time… done.
Running mktexlsr /var/lib/texmf … done.
Building format(s) --all.
        This may take some time… done.
Collecting pypandoc
  Downloading pypandoc-1.7.5.tar.gz (23.2 MB)
     |                        | 23.2 MB 52.9 MB/s
```

```
[ ]: !cp '/content/drive/MyDrive/Project 3.ipynb'  ./
```

```
[ ]: !jupyter nbconvert --to PDF "Project 3.ipynb"
```

[ ]: