baseline-syn

December 8, 2022

1 Baseline Methods for OOD Digit Classification

- Decision Tree
- Random Forest
- Regular MLP
- AdaBoost
- SVM

1.1 Data Preprocessing

Think about the following

- Should data have 3 channels or grayscale (1 channel)
- Should we use a scaler to center mean and scale to unit variance

[ ]:
```
import pickle
import numpy as np
import pandas as pd
import seaborn as sns
from sklearn import svm
from typing import Union, List
import matplotlib.pyplot as plt
from DGDataset import DGDataset
from collections import OrderedDict
from torch.utils.data import DataLoader

from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.preprocessing import label_binarize
from sklearn.preprocessing import StandardScaler
from sklearn.neural_network import MLPClassifier
from sklearn.multiclass import OneVsRestClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_curve, auc, accuracy_score, precision_score,␣
↪recall_score, mean_squared_error, classification_report, confusion_matrix,␣
↪precision_recall_curve, PrecisionRecallDisplay, RocCurveDisplay
from joblib import dump, load
```

```
/home/huakun/anaconda3/envs/AI/lib/python3.10/site-packages/tqdm/auto.py:22:
TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
```

[ ]:
```python
sns.set_style('darkgrid')
```

```
notebook controller is DISPOSED.


View Jupyter <a href='command:jupyter.viewOutput'>log</a> for further details.
```

1.2 Helper Functions

[ ]:
```python
datasets = ['mnist', 'mnist_m', 'svhn', 'syn']
target_domain = 'syn'
scaler = StandardScaler()
```

[ ]:
```python
def get_performance_metrics(predictions: np.ndarray, labels: np.ndarray):
    accuracy = accuracy_score(labels, predictions)
    precision = precision_score(labels, predictions, average='weighted')
    recall = recall_score(labels, predictions, average='weighted')
    mse = mean_squared_error(labels, predictions)
    cm = confusion_matrix(labels, predictions)
    classification_rpt = classification_report(labels, predictions,␣
 ↪output_dict=True)
    return {
        "accuracy": accuracy,
        "precision": precision,
        "recall": recall,
        "mse": mse,
        "cm": cm,
        "classification_rpt": classification_rpt,
        "classification_rpt_df": pd.DataFrame(classification_rpt).transpose()
    }
# predictions = svm_grid.predict(test_data)
# performance = get_performance_metrics(predictions, test_labels)
```

[ ]:
```python
def load_dataset(datasets: List[str], target_domain='syn', mode: str='train'):
    # datasets_ = datasets.copy()
    # datasets_.remove(target_domain)
    dataset = DGDataset(datasets, mode=mode)
    dataloader = DataLoader(dataset, batch_size=100)
    data, labels, domains = [], [], []
    for d, label, domain in dataloader:
        data.extend(d.numpy())
        labels.extend(label.numpy())
```

```
        domains.extend(domain.numpy())
    data = np.array(data)
    if len(data.shape) == 4:
        # has a color channel dimension
        data = data.reshape(len(data), np.prod(data.shape[1:])) # flatten each␣
 ↪image to a vector
    return data, labels, domains
```

[ ]:
```
train_datasets = datasets.copy()
train_datasets.remove(target_domain)
train_data, train_labels, train_domains = load_dataset(train_datasets,␣
 ↪mode='train')
val_data, val_labels, val_domains = load_dataset(train_datasets, mode='val')
test_data, test_labels, test_domains = load_dataset([target_domain],␣
 ↪mode='test')
```

1.3 SVM

[ ]:
```
parameters = {
    'kernel': ['linear', 'poly', 'rbf', 'sigmoid'],
    'C': (1, 10),
    'gamma': ('scale', 'auto'),
    'decision_function_shape': ('ovo', 'ovr')
}
svm_grid = GridSearchCV(svm.SVC(), parameters).fit(train_data, train_labels)
print("Best SVM Parameters")
for k, v in svm_grid.best_params_.items():
    print(f"\t{k}: {v}")
dump(svm_grid, './models/svm_grid.joblib')
svm_model = SVC(C=svm_grid.best_params_['C'],
                kernel=svm_grid.best_params_['kernel'],
                gamma=svm_grid.best_params_['gamma'],
                decision_function_shape=svm_grid.
 ↪best_params_['decision_function_shape']).fit(train_data, train_labels)
dump(svm_grid, './models/best_svm_model.joblib')
```

```
Best SVM Parameters
        C: 10
        decision_function_shape: ovo
        gamma: scale
        kernel: rbf
```

[ ]: ['./models/best_svm_model.joblib']

[ ]:
```
print(f"Accuracy: {round(accuracy_score(svm_model.predict(test_data),␣
 ↪test_labels) * 100, 2)}%")
```

```
Accuracy: 55.37%
```

[ ]:

```python
predictions = svm_model.predict(test_data)
svm_performance = get_performance_metrics(predictions, test_labels)
for k in ['accuracy', 'precision', 'recall', 'mse', 'cm']:
    print(f'{k}:', '\n', svm_performance[k], '\n')

svm_performance['classification_rpt_df']
```

```
accuracy:
 0.5536666666666666

precision:
 0.5585653726812658

recall:
 0.5536666666666666

mse:
 8.566166666666666

cm:
 [[352  27  16  20  38  18  50  37  27  15]
 [ 17 324  43  42  31  12  18  81  23   9]
 [ 23  30 382  22  24  17   8  62  25   7]
 [ 28  46  53 281  27  53  11  41  20  40]
 [ 11  33  23  11 445   3  24  15  13  22]
 [ 38  22  24  45  25 350  25  33  15  23]
 [113   6  14   5  45  62 299  25  20  11]
 [ 16  72  76  12   9  20  17 354  21   3]
 [ 51  10  22  10  49  78  84  18 250  28]
 [ 58  18  27   8  47  47  15  54  41 285]]
```

[ ]:

	precision	recall	f1-score	support
0	0.497878	0.586667	0.538638	600.000000
1	0.551020	0.540000	0.545455	600.000000
2	0.561765	0.636667	0.596875	600.000000
3	0.616228	0.468333	0.532197	600.000000
4	0.601351	0.741667	0.664179	600.000000
5	0.530303	0.583333	0.555556	600.000000
6	0.542650	0.498333	0.519548	600.000000
7	0.491667	0.590000	0.536364	600.000000
8	0.549451	0.416667	0.473934	600.000000
9	0.643341	0.475000	0.546500	600.000000
accuracy	0.553667	0.553667	0.553667	0.553667
macro avg	0.558565	0.553667	0.550925	6000.000000

```
weighted avg   0.558565  0.553667  0.550925  6000.000000
```

1.4 Decision Tree

[ ]:
```python
dt_clf = DecisionTreeClassifier(random_state=0)
dt_clf.fit(train_data, train_labels)
print(f"Accuracy: {round(accuracy_score(dt_clf.predict(test_data), test_labels)␣
↪* 100, 2)}%")
```

```
Accuracy: 20.57%
```

[ ]:
```python
predictions = dt_clf.predict(test_data)
dt_performance = get_performance_metrics(predictions, test_labels)
for k in ['accuracy', 'precision', 'recall', 'mse', 'cm']:
    print(f'{k}:', '\n', dt_performance[k], '\n')

dt_performance['classification_rpt_df']
```

```
accuracy:
 0.20566666666666666

precision:
 0.20719971770034468

recall:
 0.20566666666666666

mse:
 14.145166666666666

cm:
 [[119  31  46  65  43  56 101  46  49  44]
 [ 25 150  61  59  69  36  54  58  43  45]
 [ 42  48 122  55  48  55  77  68  48  37]
 [ 40  38  53 132  64  98  41  52  39  43]
 [ 52  42  46  61 135  70  61  40  44  49]
 [ 51  33  52  63  47 142  41  55  53  63]
 [ 85  24  53  37  48  81 102  60  79  31]
 [ 23  52  95  48  36  33  62 155  41  55]
 [ 67  39  50  68  52  63  50  54 100  57]
 [ 37  28  62  70  87  99  52  46  42  77]]
```

[ ]:
```
              precision    recall  f1-score      support
0              0.219963  0.198333  0.208589   600.000000
1              0.309278  0.250000  0.276498   600.000000
2              0.190625  0.203333  0.196774   600.000000
```

```
3              0.200608  0.220000  0.209857   600.000000
4              0.214626  0.225000  0.219691   600.000000
5              0.193724  0.236667  0.213053   600.000000
6              0.159126  0.170000  0.164384   600.000000
7              0.244479  0.258333  0.251216   600.000000
8              0.185874  0.166667  0.175747   600.000000
9              0.153693  0.128333  0.139873   600.000000
accuracy       0.205667  0.205667  0.205667     0.205667
macro avg      0.207200  0.205667  0.205568  6000.000000
weighted avg   0.207200  0.205667  0.205568  6000.000000
```

1.5 Random Forest

[ ]:
```
rf_clf = RandomForestClassifier(random_state=0)
rf_clf.fit(train_data, train_labels)
print(f"Accuracy: {round(accuracy_score(rf_clf.predict(test_data), test_labels)␣
↪* 100, 2)}%")
```

```
Accuracy: 39.98%
```

[ ]:
```
predictions = rf_clf.predict(test_data)
rf_performance = get_performance_metrics(predictions, test_labels)
for k in ['accuracy', 'precision', 'recall', 'mse', 'cm']:
    print(f'{k}:', '\n', rf_performance[k], '\n')

rf_performance['classification_rpt_df']
```

```
accuracy:
 0.3998333333333333

precision:
 0.3990042513214437

recall:
 0.3998333333333333

mse:
 11.009166666666667

cm:
 [[336  40  26  37  31  24  49  36  12   9]
 [ 17 294  27  43  28  21  36  84  35  15]
 [ 37  42 264  33  35  35  28  79  30  17]
 [ 34  38  38 274  28  73  18  44  21  32]
 [ 49  47  38  18 258  40  70  17  27  36]
 [ 40  21  34  60  47 265  23  56  21  33]
 [125  11  29  24  49  97 171  32  46  16]
```

```
 [ 30 128  78  14  17  18  47 226  38   4]
 [ 69  20  40  59  40  95  63  19 148  47]
 [ 54  22  24  45  99  80  28  42  43 163]]
```

[ ]:

	precision	recall	f1-score	support
0	0.424779	0.560000	0.483106	600.000000
1	0.443439	0.490000	0.465558	600.000000
2	0.441472	0.440000	0.440735	600.000000
3	0.451400	0.456667	0.454018	600.000000
4	0.408228	0.430000	0.418831	600.000000
5	0.354278	0.441667	0.393175	600.000000
6	0.320826	0.285000	0.301853	600.000000
7	0.355906	0.376667	0.365992	600.000000
8	0.351544	0.246667	0.289912	600.000000
9	0.438172	0.271667	0.335391	600.000000
accuracy	0.399833	0.399833	0.399833	0.399833
macro avg	0.399004	0.399833	0.394857	6000.000000
weighted avg	0.399004	0.399833	0.394857	6000.000000

1.6 MLP

[ ]:
```
# parameters = {
#     'activation': ('identity', 'logistic', 'tanh', 'relu'),
#     'solver': ('lbfgs', 'sgd', 'adam'),
#     'learning_rate': ('constant', 'invscaling', 'adaptive')
# }
# mlp_grid = GridSearchCV(MLPClassifier(shuffle=True), parameters).
 ↪fit(train_data, train_labels)
# print(f"Accuracy: {round(accuracy_score(mlp_grid.predict(test_data),␣
 ↪test_labels) * 100, 2)}%")
# dump(mlp_grid, './models/mlp_grid.joblib')
# mlp_clf = MLPClassifier(
#     shuffle=True,
#     activation=mlp_grid.best_params_['activation'],
#     solver=mlp_grid.best_params_['solver'],
#     learning_rate=mlp_grid.best_params_['learning_rate']).fit(train_data,␣
 ↪train_labels)
# dump(mlp_clf, './models/best_mlp.joblib')
```

```
/home/huakun/anaconda3/envs/AI/lib/python3.10/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:559:
ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
```

```
  self.n_iter_ = _check_optimize_result("lbfgs", opt_res, self.max_iter)
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packages/sklearn/neural_network/_multilayer_perceptron.py:702:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (200) reached and
the optimization hasn't converged yet.
  warnings.warn(
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```
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```

```
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  warnings.warn(
```

```
Accuracy: 65.25%
```

[ ]:
```
['./models/best_mlp.joblib']
```

[ ]:
```
# for k, v in mlp_grid.best_params_.items():
#     print(f"\t{k}: {v}")
```

```
	activation: relu
	learning_rate: invscaling
	solver: adam
```

[ ]:
```
# mlp_clf = MLPClassifier(
#     shuffle=True,
#     activation='relu',
#     solver='adam').fit(train_data, train_labels)
# dump(mlp_clf, './models/best_mlp.joblib')
# predictions = mlp_clf.predict(test_data)
# mlp_performance = get_performance_metrics(predictions, test_labels)
# for k in ['accuracy', 'precision', 'recall', 'mse', 'cm']:
#     print(f'{k}:', '\n', mlp_performance[k], '\n')

# mlp_performance['classification_rpt_df']
```

```
accuracy:
 0.6361666666666667

precision:
 0.6370873303335034

recall:
 0.6361666666666667

mse:
 6.9185

cm:
 [[408  37   7  19  24   1  21  37  25  21]
 [ 12 355  35  32  31   2   7  92  27   7]
 [ 12  17 424  25  29   9  11  44  20   9]
 [ 24  30  15 366  30  46   6  22  37  24]
 [  8  37   5   7 452   2  21  13  17  38]
 [ 22  10  11  54  10 396  18  21  20  38]
 [ 73   6   6   6  28  71 355   7  36  12]
 [  5  26  98   5  11   4   7 406  31   7]
 [ 23  10  21  23  35  48  72  10 314  44]
 [ 41  19  19   8  67  20  11  39  35 341]]
```

[ ]:

	precision	recall	f1-score	support
0	0.649682	0.680000	0.664495	600.000000
1	0.648995	0.591667	0.619006	600.000000

```
2              0.661466  0.706667  0.683320   600.000000
3              0.671560  0.610000  0.639301   600.000000
4              0.630404  0.753333  0.686409   600.000000
5              0.661102  0.660000  0.660550   600.000000
6              0.671078  0.591667  0.628875   600.000000
7              0.587554  0.676667  0.628970   600.000000
8              0.558719  0.523333  0.540448   600.000000
9              0.630314  0.568333  0.597721   600.000000
accuracy       0.636167  0.636167  0.636167     0.636167
macro avg      0.637087  0.636167  0.634910  6000.000000
weighted avg   0.637087  0.636167  0.634910  6000.000000
```

1.7 AdaBoost

[ ]:
```
adaboost_dt_base_estimator = DecisionTreeClassifier(max_depth=10)
adaboost_clf = AdaBoostClassifier(n_estimators=100, random_state=0,␣
 ↪base_estimator=adaboost_dt_base_estimator)
adaboost_clf.fit(train_data, train_labels)
print(f"Accuracy: {round(accuracy_score(adaboost_clf.predict(test_data),␣
 ↪test_labels) * 100, 2)}%")
```

[ ]:
```
predictions = adaboost_clf.predict(test_data)
adaboost_performance = get_performance_metrics(predictions, test_labels)
for k in ['accuracy', 'precision', 'recall', 'mse', 'cm']:
    print(f'{k}:', '\n', adaboost_performance[k], '\n')

adaboost_performance['classification_rpt_df']
```

```
accuracy:
 0.11116666666666666

precision:
 0.11181143598357889

recall:
 0.11116666666666666

mse:
 16.769333333333332

cm:
 [[ 79  92  30  61  82  49  57  42  44  64]
 [129  61  43  57  85  49  44  60  34  38]
 [ 78  28  56  69 105  46  60  59  58  41]
 [116  54  47  93  55  65  47  49  33  41]
 [119  69  35  39 103  62  59  54  29  31]
 [ 85  75  56  63  67  50  43  63  48  50]
```

```
 [ 67 113  42  76  65  32  36  69  59  41]
 [ 79  85  38  53  96  37  29  92  50  41]
 [105  59  43  76  77  43  48  59  55  35]
 [ 76  69  54  81  93  59  51  50  25  42]]
```

[ ]:

	precision	recall	f1-score	support
0	0.084673	0.131667	0.103066	600.000000
1	0.086525	0.101667	0.093487	600.000000
2	0.126126	0.093333	0.107280	600.000000
3	0.139222	0.155000	0.146688	600.000000
4	0.124396	0.171667	0.144258	600.000000
5	0.101626	0.083333	0.091575	600.000000
6	0.075949	0.060000	0.067039	600.000000
7	0.154104	0.153333	0.153718	600.000000
8	0.126437	0.091667	0.106280	600.000000
9	0.099057	0.070000	0.082031	600.000000
accuracy	0.111167	0.111167	0.111167	0.111167
macro avg	0.111811	0.111167	0.109542	6000.000000
weighted avg	0.111811	0.111167	0.109542	6000.000000

[ ]:

[ ]:

[ ]:

[ ]: