```
import numpy as np
import torch
import pandas as pd
import sklearn
import random

import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
```

```
import matplotlib.pyplot as plt

from mlxtend.plotting import heatmap
from sklearn.model_selection import train_test_split
from torch.utils.data import TensorDataset, DataLoader
```

```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score, accuracy_score, f1_score
```

```
## 0.001, 0.0001, 0.0003, 0.01, 0.03

batch_size    = 32
learning_rate = 0.0003 ## 0.0003
N_Epochs      = 1000

epsilon = 0.0001
```

```
path_data = '/content/drive/MyDrive/winequality-red.csv'

WINE_raw_data = pd.read_csv( path_data, delimiter="," )
```

```
WINE_raw_data
```

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphat
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.99680	3.20	0.
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.99700	3.26	0.
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.99800	3.16	0.
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.
...	...	...	...	...	...	...	...	...	...	
1594	6.2	0.600	0.08	2.0	0.090	32.0	44.0	0.99490	3.45	0.
1595	5.9	0.550	0.10	2.2	0.062	39.0	51.0	0.99512	3.52	0.
1596	6.3	0.510	0.13	2.3	0.076	29.0	40.0	0.99574	3.42	0.
1597	5.9	0.645	0.12	2.0	0.075	32.0	44.0	0.99547	3.57	0.
1598	6.0	0.310	0.47	3.6	0.067	18.0	42.0	0.99549	3.39	0.

1599 rows × 12 columns

Next steps: Generate code with `WINE_raw_data` New interactive sheet

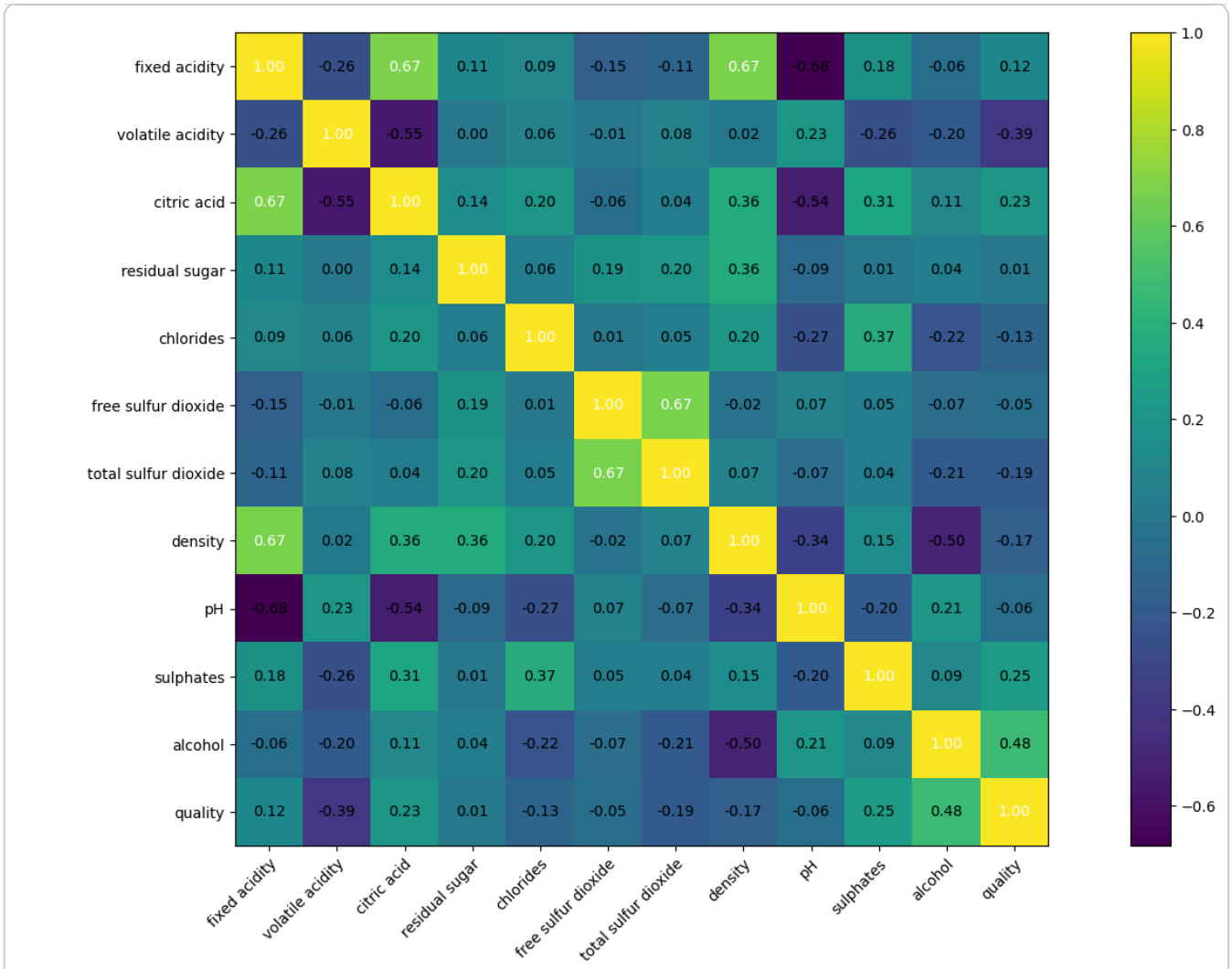
```
headers_list = WINE_raw_data.columns.values.tolist()

headers_list
```

```
['fixed acidity',
 'volatile acidity',
 'citric acid',
 'residual sugar',
 'chlorides',
 'free sulfur dioxide',
 'total sulfur dioxide',
 'density',
 'pH',
 'sulphates',
 'alcohol',
 'quality']
```

```
headers_list2 = [ 'density',
 'pH',
 'sulphates',
 'alcohol',
 'quality']
```

```
cm = np.corrcoef(   WINE_raw_data[headers_list].values.T   )
hm = heatmap(cm, row_names=headers_list, column_names=headers_list, figsize=(20,10))
plt.show()
```




```
WINE_raw_data_np = WINE_raw_data.to_numpy()
```

```
WINE_raw_data_np
```

```
array([[ 7.4  ,  0.7  ,  0.   , ...,  0.56 ,  9.4  ,  5.   ],
       [ 7.8  ,  0.88 ,  0.   , ...,  0.68 ,  9.8  ,  5.   ],
       [ 7.8  ,  0.76 ,  0.04 , ...,  0.65 ,  9.8  ,  5.   ],
       ...,
       [ 6.3  ,  0.51 ,  0.13 , ...,  0.75 , 11.   ,  6.   ],
       [ 5.9  ,  0.645,  0.12 , ...,  0.71 , 10.2  ,  5.   ],
       [ 6.   ,  0.31 ,  0.47 , ...,  0.66 , 11.   ,  6.   ]])
```

```
WINE_raw_data_np.shape
```

```
(1599, 12)
```

```
X = WINE_raw_data_np[:, :-1]


y = WINE_raw_data_np[:, 11:12]
```

```
y
```

```
array([[5.],
       [5.],
       [5.],
       ...,
       [6.],
       [5.],
       [6.]])
```

```
y = y.astype(int)
```

```
y
```

```
array([[5],
       [5],
       [5],
       ...,
       [6],
       [5],
       [6]])
```

```
the_set = np.unique(y)

the_set
```

```
array([3, 4, 5, 6, 7, 8])
```

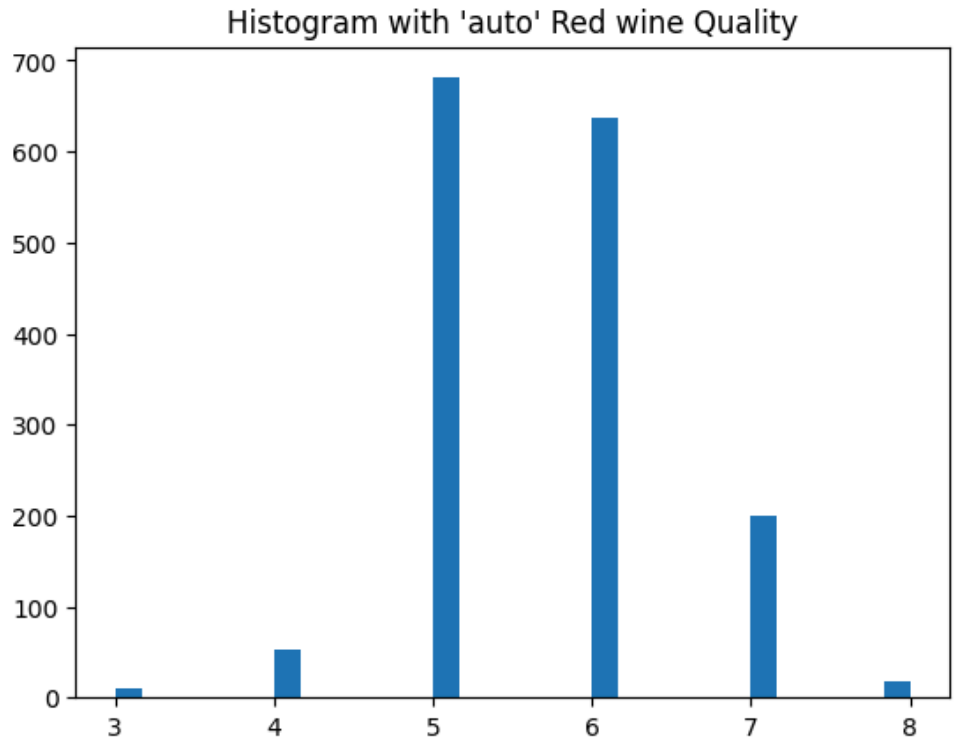
```
len(  the_set  )
```

```
6
```

```
_ = plt.hist(y, bins='auto')

plt.title("Histogram with 'auto' Red wine Quality")

plt.show()
```




```
print(X.shape)

print(y.shape)
```

```
(1599, 11)
(1599, 1)
```

```
random_seed = int( random.random() * 100 )     ## 42
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=random
```

```
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(1279, 11)
(320, 11)
(1279, 1)
(320, 1)
```

```
X_test.dtype
```

```
dtype('float64')
```

```
y_test.dtype
```

```
dtype('int64')
```

```
## fix data type

X_train = X_train.astype(  np.float32  )
X_test  = X_test.astype(   np.float32  )
y_train = y_train.astype(  np.int64 )       ## np.long
y_test  = y_test.astype(   np.int64 )
```

```
X_train_tr = torch.from_numpy(X_train)
X_test_tr  = torch.from_numpy(X_test)
y_train_tr = torch.from_numpy(y_train)
y_test_tr  = torch.from_numpy(y_test)
```

```
x_means      = X_train_tr.mean(0, keepdim=True )

x_deviations = X_train_tr.std( 0, keepdim=True) + epsilon
```

```
x_means
```

```
tensor([[ 8.3513,  0.5274,  0.2747,  2.5441,  0.0880, 16.0731, 47.3065,  0.9968,
          3.3096,  0.6592, 10.4287]])
```

```
x_deviations
```

```
tensor([[1.7635e+00, 1.7971e-01, 1.9223e-01, 1.4084e+00, 4.9522e-02, 1.0694e+01,
         3.3663e+01, 2.0134e-03, 1.5759e-01, 1.7533e-01, 1.0778e+00]])
```

```
X_train.shape[0]
```

```
1279
```

```
## label_map = {0:0, 2:1 }
## the_set = array([ 3,   4,   5,   6,   7,   8,   9   ])

label_map         = { 3:0, 4:1, 5:2, 6:3, 7:4, 8:5, 9:6 }
reverse_label_map = { 0:3, 1:4, 2:5, 3:6, 4:7, 5:8, 6:9 }
```

```
wine_train_list = [  ( X_train_tr[i], label_map[ y_train_tr[i].item() ] )  for i in range( X

wine_test_list  = [  ( X_test_tr[i],  label_map[ y_test_tr[i].item()  ] )  for i in range( X
```

```
train_dl = torch.utils.data.DataLoader(wine_train_list, batch_size=batch_size, shuffle=True)
```

```
all_test_data = X_test.shape[0]

test_dl  = torch.utils.data.DataLoader(wine_test_list,  batch_size=all_test_data, shuffle=Tr
```

```
train_dl
```

```
<torch.utils.data.dataloader.DataLoader at 0x791cff38e2d0>
```

```
## MLP
```

```
class MLP_Net(nn.Module):
    ## init the class
    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations

        self.linear1 = nn.Linear(11, 5)
        self.act1    = nn.ReLU()   ## nn.Sigmoid()
        self.linear2 = nn.Linear(5, 7)
        self.act2    = nn.Softmax(dim=1)
        self.dropout = nn.Dropout(0.25)


    ## perform inference
    def forward(self, x):

        ## x      = (x - self.x_means) / self.x_deviations

        x      = self.linear1(x)
        x      = self.act1(x)
        ## x      = self.dropout(x)
        x      = self.linear2(x)
        y_pred = self.act2(x)

        return y_pred
```

```
## Deep Learning with 2 hidden layers

class DL_Net(nn.Module):

    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations

        self.linear1 = nn.Linear(11, 15)
        self.act1    = nn.ReLU()
        self.linear2 = nn.Linear(15, 9)
        self.act2    = nn.ReLU()
        self.linear3 = nn.Linear(9, 7)
        self.act3    = nn.Softmax(dim=1)
        self.dropout = nn.Dropout(0.25)

    ## perform inference
    def forward(self, x):

        x      = (x - self.x_means) / self.x_deviations

        x      = self.linear1(x)
        x      = self.act1(x)
        x      = self.dropout(x)
        x      = self.linear2(x)
        x      = self.act2(x)
        x      = self.dropout(x)
```

```
        x      = self.linear3(x)
        y_pred = self.act3(x)

        return y_pred
```

```
def training_loop( N_Epochs, model, loss_fn, opt  ):

    for epoch in range(N_Epochs):
        for xb, yb in train_dl:

            ## yb = torch.squeeze(yb, dim=1)

            y_pred = model(xb)
            ## print(    yb.shape   )
            ## print( y_pred.shape  )
            loss   = loss_fn(y_pred, yb)

            opt.zero_grad()
            loss.backward()
            opt.step()

        if epoch % 50 == 0:
            print(epoch, "loss=", loss)
```

```
model      = MLP_Net( x_means, x_deviations  )

opt        = torch.optim.Adam(    model.parameters(), lr=learning_rate )

## the y_test data can be integers and does not need to be one hot encoded with this functio
loss_fn    = nn.CrossEntropyLoss( )

training_loop(  N_Epochs, model, loss_fn, opt  )
```

```
0 loss= tensor(2.0410, grad_fn=<NllLossBackward0>)
50 loss= tensor(1.8105, grad_fn=<NllLossBackward0>)
100 loss= tensor(1.6969, grad_fn=<NllLossBackward0>)
150 loss= tensor(1.6461, grad_fn=<NllLossBackward0>)
200 loss= tensor(1.6151, grad_fn=<NllLossBackward0>)
250 loss= tensor(1.6664, grad_fn=<NllLossBackward0>)
300 loss= tensor(1.6596, grad_fn=<NllLossBackward0>)
350 loss= tensor(1.6027, grad_fn=<NllLossBackward0>)
400 loss= tensor(1.7353, grad_fn=<NllLossBackward0>)
450 loss= tensor(1.6861, grad_fn=<NllLossBackward0>)
500 loss= tensor(1.6303, grad_fn=<NllLossBackward0>)
550 loss= tensor(1.5196, grad_fn=<NllLossBackward0>)
600 loss= tensor(1.5869, grad_fn=<NllLossBackward0>)
650 loss= tensor(1.5924, grad_fn=<NllLossBackward0>)
700 loss= tensor(1.6084, grad_fn=<NllLossBackward0>)
750 loss= tensor(1.7028, grad_fn=<NllLossBackward0>)
800 loss= tensor(1.6881, grad_fn=<NllLossBackward0>)
850 loss= tensor(1.5797, grad_fn=<NllLossBackward0>)
900 loss= tensor(1.6094, grad_fn=<NllLossBackward0>)
950 loss= tensor(1.6292, grad_fn=<NllLossBackward0>)
```

```
def print_metrics_function(y_test, y_pred):
    print('Accuracy: %.2f' % accuracy_score(y_test, y_pred))
    confmat = confusion_matrix(y_true=y_test, y_pred=y_pred)
    print("Confusion Matrix:")
```

```
    print(confmat)
    print('Precision: %.3f' % precision_score(y_true=y_test, y_pred=y_pred, average='weighte
    print('Recall: %.3f' % recall_score(y_true=y_test, y_pred=y_pred, average='weighted'))
    print('F1-measure: %.3f' % f1_score(y_true=y_test, y_pred=y_pred, average='weighted'))
```

```
with torch.no_grad():
    for x_real, y_real in test_dl:
        y_pred = model(  x_real  )
        vals, indeces = torch.max( y_pred, dim=1  )
        preds = indeces
        print_metrics_function(y_real, preds)
```

```
Accuracy: 0.57
Confusion Matrix:
[[ 0  0  0  1  0  0]
 [ 0  0  4  3  0  0]
 [ 0  0 99 32  0  0]
 [ 0  0 49 82  0  0]
 [ 0  0  3 44  0  0]
 [ 0  0  0  3  0  0]]
Precision: 0.465
Recall: 0.566
F1-measure: 0.510
/usr/local/lib/python3.12/dist-packages/sklearn/metrics/_classification.py:1565: UndefinedMet
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

```
model      = DL_Net( x_means, x_deviations  )

opt        = torch.optim.Adam(    model.parameters(), lr=learning_rate )

## the y_test data can be integers and does not need to be one hot encoded with this functio
loss_fn    = nn.CrossEntropyLoss( )

training_loop(  N_Epochs, model, loss_fn, opt  )
```

```
0 loss= tensor(1.9598, grad_fn=<NllLossBackward0>)
50 loss= tensor(1.6419, grad_fn=<NllLossBackward0>)
100 loss= tensor(1.6496, grad_fn=<NllLossBackward0>)
150 loss= tensor(1.6941, grad_fn=<NllLossBackward0>)
200 loss= tensor(1.5744, grad_fn=<NllLossBackward0>)
250 loss= tensor(1.7327, grad_fn=<NllLossBackward0>)
300 loss= tensor(1.5962, grad_fn=<NllLossBackward0>)
350 loss= tensor(1.3774, grad_fn=<NllLossBackward0>)
400 loss= tensor(1.4984, grad_fn=<NllLossBackward0>)
450 loss= tensor(1.4469, grad_fn=<NllLossBackward0>)
500 loss= tensor(1.6185, grad_fn=<NllLossBackward0>)
550 loss= tensor(1.5444, grad_fn=<NllLossBackward0>)
600 loss= tensor(1.6168, grad_fn=<NllLossBackward0>)
650 loss= tensor(1.6504, grad_fn=<NllLossBackward0>)
700 loss= tensor(1.5961, grad_fn=<NllLossBackward0>)
750 loss= tensor(1.6777, grad_fn=<NllLossBackward0>)
800 loss= tensor(1.4027, grad_fn=<NllLossBackward0>)
850 loss= tensor(1.4904, grad_fn=<NllLossBackward0>)
900 loss= tensor(1.6219, grad_fn=<NllLossBackward0>)
950 loss= tensor(1.5634, grad_fn=<NllLossBackward0>)
```

```
with torch.no_grad():
    for x_real, y_real in test_dl:
        ## batch_size = imgs.shape[0]
```

```
        y_pred = model(  x_real  )
        vals, indeces = torch.max( y_pred, dim=1  )
        preds = indeces
        print_metrics_function(y_real, preds)
```

```
Accuracy: 0.59
Confusion Matrix:
[[  0   0   0   1   0   0]
 [  0   0   5   2   0   0]
 [  0   0 103  28   0   0]
 [  0   0  45  86   0   0]
 [  0   0   6  41   0   0]
 [  0   0   0   3   0   0]]
Precision: 0.484
Recall: 0.591
F1-measure: 0.532
/usr/local/lib/python3.12/dist-packages/sklearn/metrics/_classification.py:1565: UndefinedMet
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

```
Start coding or generate with AI.
```

Regression

```
import numpy as np
import torch
import pandas as pd
import sklearn
import random

import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
```

```
import matplotlib.pyplot as plt

from mlxtend.plotting import heatmap
from sklearn.model_selection import train_test_split
from torch.utils.data import TensorDataset, DataLoader

## coefficient of determination
from sklearn.metrics import r2_score
```

```
import xgboost as xgb
```

```
!pip install onnxmltools
!pip install onnxruntime
```

```
Requirement already satisfied: onnxmltools in /usr/local/lib/python3.12/dist-packages (1.14.0
Requirement already satisfied: numpy in /usr/local/lib/python3.12/dist-packages (from onnxmlt
Requirement already satisfied: onnx in /usr/local/lib/python3.12/dist-packages (from onnxmlto
Requirement already satisfied: protobuf>=4.25.1 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: typing_extensions>=4.7.1 in /usr/local/lib/python3.12/dist-pac
Requirement already satisfied: ml_dtypes>=0.5.0 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: onnxruntime in /usr/local/lib/python3.12/dist-packages (1.23.2
Requirement already satisfied: coloredlogs in /usr/local/lib/python3.12/dist-packages (from o
```

```
Requirement already satisfied: flatbuffers in /usr/local/lib/python3.12/dist-packages (from o
Requirement already satisfied: numpy>=1.21.6 in /usr/local/lib/python3.12/dist-packages (from
Requirement already satisfied: packaging in /usr/local/lib/python3.12/dist-packages (from onn
Requirement already satisfied: protobuf in /usr/local/lib/python3.12/dist-packages (from onnx
Requirement already satisfied: sympy in /usr/local/lib/python3.12/dist-packages (from onnxrun
Requirement already satisfied: humanfriendly>=9.1 in /usr/local/lib/python3.12/dist-packages
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.12/dist-packages
```

```
!pip install skl2onnx
```

```
Requirement already satisfied: skl2onnx in /usr/local/lib/python3.12/dist-packages (1.19.1)
Requirement already satisfied: onnx>=1.2.1 in /usr/local/lib/python3.12/dist-packages (from s
Requirement already satisfied: scikit-learn>=1.1 in /usr/local/lib/python3.12/dist-packages (
Requirement already satisfied: numpy>=1.22 in /usr/local/lib/python3.12/dist-packages (from o
Requirement already satisfied: protobuf>=4.25.1 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: typing_extensions>=4.7.1 in /usr/local/lib/python3.12/dist-pac
Requirement already satisfied: ml_dtypes>=0.5.0 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: scipy>=1.6.0 in /usr/local/lib/python3.12/dist-packages (from
Requirement already satisfied: joblib>=1.2.0 in /usr/local/lib/python3.12/dist-packages (from
Requirement already satisfied: threadpoolctl>=3.1.0 in /usr/local/lib/python3.12/dist-package
```

```
import onnxruntime as rt
import onnxmltools

from skl2onnx.common.data_types import FloatTensorType
```

```
## 0.001, 0.0001, 0.0003, 0.01, 0.03

batch_size    = 16
learning_rate = 0.005 ## 0.001
N_Epochs      = 100

epsilon = 0.0001
```

```
path_data = '/content/drive/MyDrive/winequality-red.csv'

WINE_raw_data = pd.read_csv( path_data, sep=",")
```

```
WINE_raw_data
```

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphat
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.99680	3.20	0.
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.99700	3.26	0.
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.99800	3.16	0.
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.
...	...	...	...	...	...	...	...	...	...	
1594	6.2	0.600	0.08	2.0	0.090	32.0	44.0	0.99490	3.45	0.
1595	5.9	0.550	0.10	2.2	0.062	39.0	51.0	0.99512	3.52	0.
1596	6.3	0.510	0.13	2.3	0.076	29.0	40.0	0.99574	3.42	0.
1597	5.9	0.645	0.12	2.0	0.075	32.0	44.0	0.99547	3.57	0.
1598	6.0	0.310	0.47	3.6	0.067	18.0	42.0	0.99549	3.39	0.

1599 rows × 12 columns

Next steps: Generate code with `WINE_raw_data` New interactive sheet

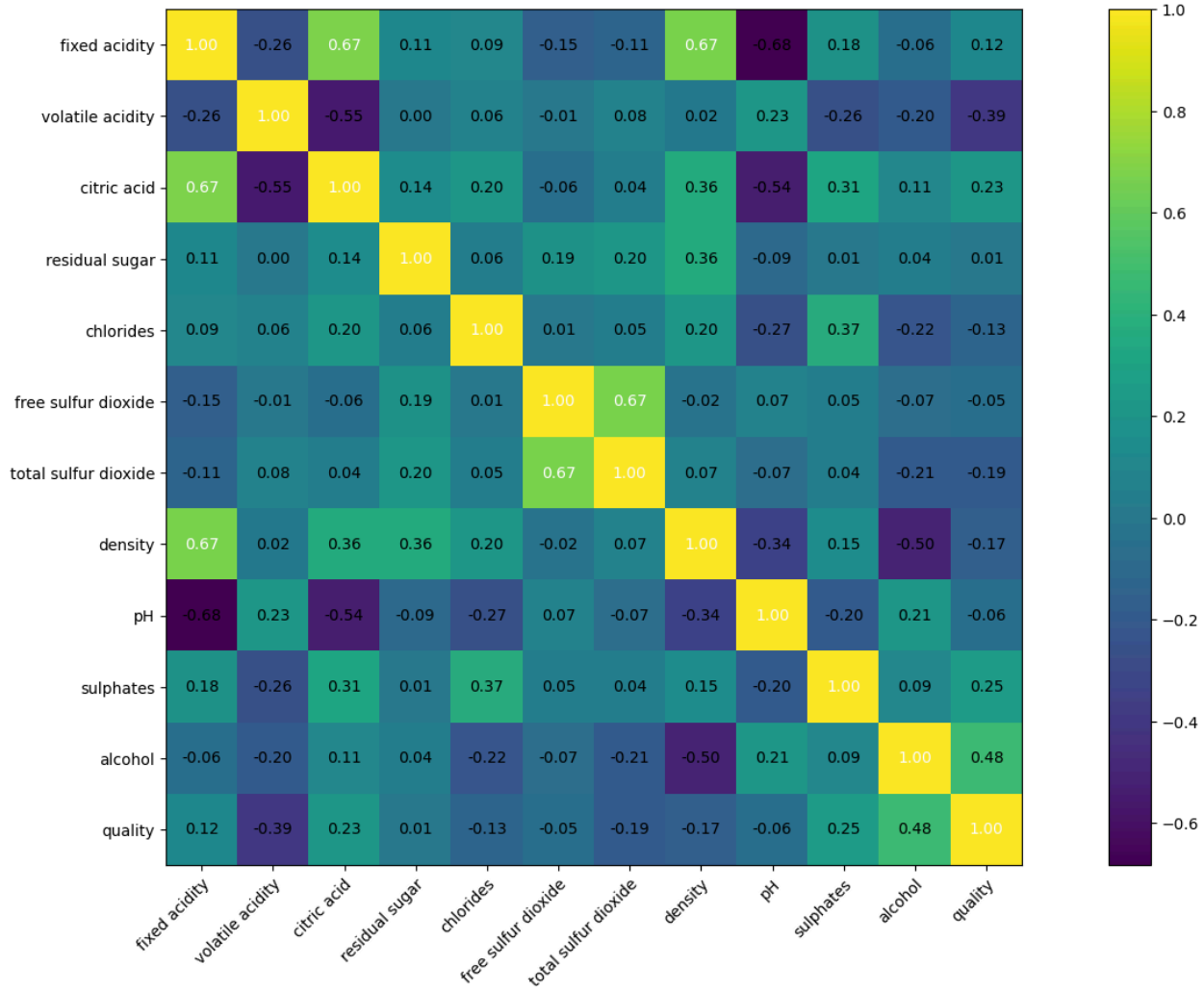
```
headers_list = WINE_raw_data.columns.values.tolist()

headers_list
```

```
['fixed acidity',
 'volatile acidity',
 'citric acid',
 'residual sugar',
 'chlorides',
 'free sulfur dioxide',
 'total sulfur dioxide',
 'density',
 'pH',
 'sulphates',
 'alcohol',
 'quality']
```

```
headers_list2 = [ 'density',
 'pH',
 'sulphates',
 'alcohol',
 'quality']
```

```
cm = np.corrcoef(   WINE_raw_data[headers_list].values.T   )
hm = heatmap(cm, row_names=headers_list, column_names=headers_list, figsize=(20,10))
plt.show()
```




```
## Convert Pandas to Numpy

WINE_raw_data_np = WINE_raw_data.to_numpy()
```

```
WINE_raw_data_np
```

```
array([[ 7.4  ,  0.7  ,  0.   , ...,  0.56 ,  9.4  ,  5.   ],
       [ 7.8  ,  0.88 ,  0.   , ...,  0.68 ,  9.8  ,  5.   ],
       [ 7.8  ,  0.76 ,  0.04 , ...,  0.65 ,  9.8  ,  5.   ],
       ...,
       [ 6.3  ,  0.51 ,  0.13 , ...,  0.75 , 11.   ,  6.   ],
       [ 5.9  ,  0.645,  0.12 , ...,  0.71 , 10.2  ,  5.   ],
       [ 6.   ,  0.31 ,  0.47 , ...,  0.66 , 11.   ,  6.   ]])
```

```
WINE_raw_data_np.shape
```

```
(1599, 12)
```

```
X = WINE_raw_data_np[:, :-1]


y = WINE_raw_data_np[:, 11:12]
```

```
y
```

```
array([[5.],
       [5.],
       [5.],
       ...,
       [6.],
       [5.],
       [6.]])
```

```
print(X.shape)

print(y.shape)
```

```
(1599, 11)
(1599, 1)
```

```
random_seed = int( random.random() * 100 )     ## 42
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=random
y_train = y_train.ravel() # Flatten y_train
y_test = y_test.ravel()   # Flatten y_test
```

```
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(1279, 11)
(320, 11)
(1279,)
(320,)
```

```
y_test.dtype
```

```
dtype('float64')
```

```
## fix data type

X_train = X_train.astype(  np.float32  )
X_test  = X_test.astype(   np.float32  )
y_train = y_train.astype(  np.float32  )
y_test  = y_test.astype(   np.float32  )
```

```
X_train_tr = torch.from_numpy(X_train)
X_test_tr  = torch.from_numpy(X_test)
y_train_tr = torch.from_numpy(y_train)
y_test_tr  = torch.from_numpy(y_test)
```

```
x_means      = X_train_tr.mean(0, keepdim=True )

x_deviations = X_train_tr.std( 0, keepdim=True) + epsilon
```

```
x_means
```

```
tensor([[ 8.3226,  0.5328,  0.2701,  2.5328,  0.0884, 15.8819, 46.7686,  0.9967,
          3.3089,  0.6629, 10.4272]])
```

```
x_deviations
```

```
tensor([[1.7472e+00, 1.7915e-01, 1.9621e-01, 1.3984e+00, 5.1017e-02, 1.0479e+01,
         3.3325e+01, 1.9875e-03, 1.5778e-01, 1.7741e-01, 1.0737e+00]])
```

```
train_ds = TensorDataset( X_train_tr, y_train_tr  )
```

```
train_dl = DataLoader( train_ds, batch_size, shuffle=True  )
```

```
train_dl
```

```
<torch.utils.data.dataloader.DataLoader at 0x791cff66d6d0>
```

```
## Linear Regression

class LinRegNet(nn.Module):
    ## init the class
    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations

        self.linear1 = nn.Linear(11, 1)

    ## perform inference
    def forward(self, x):

        x = (x - self.x_means) / self.x_deviations

        y_pred = self.linear1(x)
        ## return torch.round( y_pred )
        return y_pred
```

```
## MLP

class MLP_Net(nn.Module):
    ## init the class
    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations
```

```
        self.linear1 = nn.Linear(11, 8)
        self.act1    = nn.Sigmoid()
        self.linear2 = nn.Linear(8, 1)
        self.dropout = nn.Dropout(0.25)

    ## perform inference
    def forward(self, x):

        x = (x - self.x_means) / self.x_deviations

        x = self.linear1(x)
        x = self.act1(x)
        x = self.dropout(x)
        y_pred = self.linear2(x)

        ## return torch.round( y_pred )
        return y_pred
```

```
## Deep Learning with 2 hidden layers

class DL_Net(nn.Module):
    ## init the class
    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations

        self.linear1 = nn.Linear(11, 10)
        self.act1    = nn.ReLU()
        self.linear2 = nn.Linear(10, 6)
        self.act2    = nn.ReLU()
        self.linear3 = nn.Linear(6, 1)
        self.dropout = nn.Dropout(0.25)

    ## perform inference
    def forward(self, x):

        x = (x - self.x_means) / self.x_deviations

        x = self.linear1(x)
        x = self.act1(x)
        x = self.linear2(x)
        x = self.act2(x)
        ## x = self.dropout(x)
        y_pred = self.linear3(x)

        ## return torch.round( y_pred )
        return y_pred
```

```
## Linear plus Nonlinear
## f1 + f2

class LinearPlusNonLinear_Net(nn.Module):
    ## init the class
```

```
    def __init__(self, x_means, x_deviations):
        super().__init__()

        self.x_means      = x_means
        self.x_deviations = x_deviations

        ## F1
        self.f1_linear1 = nn.Linear(11, 1)

        ## F2
        self.f2_linear1 = nn.Linear(11, 14)
        self.f2_act1    = nn.Sigmoid()
        self.f2_linear2 = nn.Linear(14, 1)


    ## perform inference
    def forward(self, x):

        x = (x - self.x_means) / self.x_deviations

        ## F1
        f1 = self.f1_linear(x)

        ## F2
        f2 = self.f2_linear1(x)
        f2 = self.f2_act1(f2)
        f2 = self.f2_linear2(f2)

        y_pred = f1 + f2

        ## return torch.round( y_pred )
        return y_pred
```

```
def training_loop( N_Epochs, model, loss_fn, opt  ):

    for epoch in range(N_Epochs):
        for xb, yb in train_dl:

            y_pred = model(xb)
            loss   = loss_fn(y_pred, yb)

            opt.zero_grad()
            loss.backward()
            opt.step()

        if epoch % 20 == 0:
            print(epoch, "loss=", loss)
```

```
## model = LinRegNet( x_means, x_deviations  )
model = DL_Net( x_means, x_deviations  )

opt     = torch.optim.Adam(    model.parameters(), lr=learning_rate )
loss_fn = F.mse_loss

training_loop(  N_Epochs, model, loss_fn, opt  )
```

```
/tmp/ipython-input-3722981469.py:7: UserWarning: Using a target size (torch.Size([16])) that
  loss   = loss_fn(y_pred, yb)
/tmp/ipython-input-3722981469.py:7: UserWarning: Using a target size (torch.Size([15])) that
  loss   = loss_fn(y_pred, yb)
0 loss= tensor(2.0632, grad_fn=<MseLossBackward0>)
20 loss= tensor(0.6712, grad_fn=<MseLossBackward0>)
40 loss= tensor(0.5318, grad_fn=<MseLossBackward0>)
60 loss= tensor(0.6456, grad_fn=<MseLossBackward0>)
80 loss= tensor(0.4076, grad_fn=<MseLossBackward0>)
```

```
y_pred_test = model( X_test_tr )
```

```
y_pred_test.shape
```

```
torch.Size([320, 1])
```

```
print( "Testing R**2: ", r2_score(  y_test_tr.numpy(),  y_pred_test.detach().numpy()     )
```

```
Testing R**2:  0.04607212543487549
```

```
y_pred_test.shape
```

```
torch.Size([320, 1])
```

```
y_test_tr.shape
```

```
torch.Size([320])
```

```
len(X_test_tr)
```

```
320
```

```
list_preds = []
list_reals = []

for i in range(len(X_test_tr)):
    print("************************************")
    print("pred, real")
    np_real =   y_test_tr[i].detach().numpy()
    np_pred = y_pred_test[i].detach().numpy()
    print(( np_pred  , np_real))
    list_preds.append(np_pred[0])
    list_reals.append(np_real)
```

```
pred, real
(array([5.535102], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.4735847], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.5465126], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.48017], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.5297256], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.3923326], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.507065], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.592706], dtype=float32), array(7., dtype=float32))
**********
pred, real
(array([5.42469], dtype=float32), array(6., dtype=float32))
**********
pred, real
(array([5.5182767], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.63585], dtype=float32), array(6., dtype=float32))
**********
pred, real
(array([5.511641], dtype=float32), array(5., dtype=float32))
**********
pred, real
(array([5.6110187], dtype=float32), array(7., dtype=float32))
**********
pred, real
(array([5.4588084], dtype=float32), array(6., dtype=float32))
**********
pred, real
(array([5.498214], dtype=float32), array(5., dtype=float32))
**********
pred, real
```

```
model.eval()

dummy_input = torch.randn(1, 11)

input_names  = ["input1"]
output_names = ["output1"]

torch.onnx.export(
        model,
        dummy_input,
        "DLnet_WineData.onnx",
        verbose=False,
        input_names = input_names,
        output_names = output_names
```

```
)
```

```
/tmp/ipython-input-1047114702.py:8: DeprecationWarning: You are using the legacy TorchScript-
  torch.onnx.export(
```

```
regressor = xgb.XGBRegressor(
        n_estimators=100,
        reg_lambda=1,
        gamma=0,
        max_depth=3,
        base_score=0.5 # Explicitly set base_score here
)
```

```
initial_types = [('input', FloatTensorType([None, X_train.shape[1]]))]
regressor.fit(X_train, y_train)
onnx_model = onnxmltools.convert_xgboost(regressor, initial_types=initial_types)
onnxmltools.utils.save_model(onnx_model, '/content/drive/MyDrive/winequality-red.onnx') # Co
```

```
y_pred = regressor.predict(X_test)
```

```
y_pred.shape
```

```
(320,)
```

```
y_pred
```

```
array([5.5389094, 5.007868 , 5.9522457, 5.1718526, 5.9111795, 5.963515 ,
       5.0650363, 5.945048 , 6.5487943, 6.457026 , 5.1587744, 5.5703087,
       6.4704413, 5.720422 , 6.3885374, 5.933399 , 6.709471 , 5.216052 ,
       5.39906  , 6.085132 , 4.72235  , 6.4893575, 6.100801 , 6.1952243,
       5.239799 , 5.1573663, 5.051047 , 5.823911 , 4.898356 , 5.5688295,
       5.249448 , 5.529216 , 6.585831 , 5.05363  , 4.8307304, 5.8087106,
       5.4878573, 7.009579 , 5.625086 , 5.7732205, 5.144773 , 5.573109 ,
       5.7000594, 6.39421  , 5.2900987, 4.8525963, 6.2366056, 5.1569533,
       4.4430046, 6.076347 , 5.448103 , 5.748086 , 5.106331 , 5.047274 ,
       5.4021945, 5.76423  , 5.752764 , 6.3885374, 6.3911033, 4.90529  ,
       4.560435 , 5.4021726, 4.778679 , 6.534351 , 5.506236 , 6.1205816,
       4.8041935, 5.476138 , 5.7621565, 5.016196 , 5.5155478, 6.121264 ,
       6.45612  , 4.9287987, 4.855111 , 5.4271193, 5.7809834, 5.61229  ,
       5.8466897, 5.389967 , 4.926868 , 6.269507 , 5.684498 , 5.4353228,
       4.9850636, 5.948963 , 5.241265 , 6.5219965, 6.5746107, 5.8178854,
       5.5979557, 5.9196906, 6.4970393, 3.5973303, 5.0384097, 6.7041483,
       5.9716787, 5.036917 , 4.879459 , 6.378269 , 4.737654 , 5.2393007,
       7.14879  , 5.689186 , 4.229621 , 5.4477715, 5.129891 , 5.7186427,
       5.8050685, 5.689946 , 6.4971876, 6.179412 , 5.1619   , 6.5882573,
       6.170074 , 4.9976597, 5.2093477, 5.6167965, 5.3466454, 5.9046283,
       5.905822 , 4.9025173, 6.115522 , 5.156191 , 5.3186555, 7.226321 ,
       5.1449366, 5.916018 , 5.219388 , 5.7897243, 5.4144483, 4.9279203,
       5.06983  , 5.512523 , 5.163509 , 6.562802 , 5.182211 , 6.162331 ,
       5.9866776, 5.859933 , 4.944874 , 6.7368627, 6.6819997, 5.401082 ,
       6.7561846, 6.321351 , 4.7346787, 5.8570776, 5.9674807, 5.9399414,
       5.0359626, 6.1153183, 5.907895 , 5.3549333, 5.9602566, 6.282799 ,
       5.5264893, 4.6778555, 5.4032416, 5.8581614, 4.9225087, 6.809212 ,
       6.2120457, 5.12801  , 5.2246504, 6.4289203, 5.336259 , 5.405274 ,
       5.5010595, 6.4553137, 5.9206443, 5.085847 , 6.1143494, 4.8531938,
       6.343911 , 5.621895 , 5.646603 , 5.414417 , 5.761234 , 5.9756236,
       5.6419644, 6.4970393, 5.6306486, 5.302618 , 5.241518 , 6.228949 ,
```

```
        6.082586 , 5.312232 , 6.5334725, 5.5155478, 5.5332365, 5.1888895,
        6.202011 , 6.5179496, 5.2825527, 5.949467 , 6.4654193, 6.603234 ,
        5.6705275, 5.582663 , 5.876026 , 5.2639546, 5.742848 , 5.26636  ,
        5.207004 , 5.1744246, 5.9004135, 5.5332365, 6.178779 , 5.656308 ,
        5.422463 , 5.8581614, 4.984695 , 5.552852 , 6.5079284, 5.0343575,
        6.0668464, 5.09233  , 4.6663923, 5.689466 , 4.521391 , 5.0173473,
        6.115401 , 6.6705265, 5.5230703, 5.9088397, 5.0650535, 5.182211 ,
        5.6343045, 5.9720106, 6.930607 , 5.918904 , 6.8205695, 5.185098 ,
        5.163323 , 5.9606996, 6.326925 , 5.3862348, 5.1293073, 5.407542 ,
        6.5268226, 6.322717 , 5.1897492, 5.528924 , 6.2761927, 5.2103753,
        4.4646263, 5.450758 , 4.995759 , 4.562037 , 6.7640157, 5.2847195,
        5.317123 , 5.0148697, 4.874751 , 5.956521 , 5.6164665, 5.2595315,
        6.034378 , 6.1284385, 5.9789   , 5.4913173, 5.073286 , 5.0105753,
        5.216052 , 5.0993733, 6.3793883, 6.33547  , 5.993724 , 5.5261354,
        6.468635 , 4.927186 , 5.513778 , 5.9222956, 5.93615  , 5.106331 ,
        5.375753 , 4.966629 , 5.4626822, 5.6430383, 5.5417533, 6.3528004,
        5.1907454, 6.2811084, 6.0295033, 5.029631 , 6.2097054, 5.133874 ,
        5.041613 , 5.15929  , 5.472853 , 4.8525963, 6.0986385, 6.008149 ,
        4.806336 , 6.326076 , 5.142671 , 5.2873025, 6.490361 , 5.0538173,
        5.8464875, 5.6754656, 5.5090117, 5.2335443, 6.999466 , 5.7227035,
        5.76423  , 5.625086 , 5.0273623, 5.3315682, 6.1390266, 5.8782306,
        5.4021726, 5.144078 , 5.7867393, 5.6463065, 5.389967 , 5.723044 ,
        5.2528095, 5.552852 ], dtype=float32)
```

```
!pip install -U onnxmltools skl2onnx
!pip install xgboost==1.6.2
```

```
Requirement already satisfied: onnxmltools in /usr/local/lib/python3.12/dist-packages (1.14.0
Requirement already satisfied: skl2onnx in /usr/local/lib/python3.12/dist-packages (1.19.1)
Requirement already satisfied: numpy in /usr/local/lib/python3.12/dist-packages (from onnxmlt
Requirement already satisfied: onnx in /usr/local/lib/python3.12/dist-packages (from onnxmlto
Requirement already satisfied: scikit-learn>=1.1 in /usr/local/lib/python3.12/dist-packages (
Requirement already satisfied: protobuf>=4.25.1 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: typing_extensions>=4.7.1 in /usr/local/lib/python3.12/dist-pac
Requirement already satisfied: ml_dtypes>=0.5.0 in /usr/local/lib/python3.12/dist-packages (f
Requirement already satisfied: scipy>=1.6.0 in /usr/local/lib/python3.12/dist-packages (from
Requirement already satisfied: joblib>=1.2.0 in /usr/local/lib/python3.12/dist-packages (from
Requirement already satisfied: threadpoolctl>=3.1.0 in /usr/local/lib/python3.12/dist-package
Requirement already satisfied: xgboost==1.6.2 in /usr/local/lib/python3.12/dist-packages (1.6
Requirement already satisfied: numpy in /usr/local/lib/python3.12/dist-packages (from xgboost
Requirement already satisfied: scipy in /usr/local/lib/python3.12/dist-packages (from xgboost
```

```
initial_types = [(
          'float_input',
          FloatTensorType(  [None, 11 ]  )

)]
```

```
onnx_model = onnxmltools.convert_xgboost(regressor, initial_types=initial_types)

onnxmltools.utils.save_model(onnx_model, '/content/DLnet_WineData.onnx')
```

```
sess = rt.InferenceSession('/content/DLnet_WineData.onnx')
```

```
input_name = sess.get_inputs()[0].name
```

```
input_name
```

```
'float_input'
```

```
label_name = sess.get_outputs()[0].name
```

```
label_name
```

```
'variable'
```

```
pred_ort = sess.run(  [label_name], {input_name: X_test.astype(np.float32)}  )
```

```
pred_ort[0]
```

```
array([[5.538909 ],
       [5.007868 ],
       [5.9522457],
       [5.1718526],
       [5.9111795],
       [5.963515 ],
       [5.0650363],
       [5.9450474],
       [6.5487943],
       [6.457026 ],
       [5.158774 ],
       [5.5703087],
       [6.4704413],
       [5.720422 ],
       [6.3885374],
       [5.933399 ],
       [6.709471 ],
       [5.216052 ],
       [5.39906  ],
       [6.085132 ],
       [4.72235  ],
       [6.4893575],
       [6.100801 ],
       [6.1952243],
       [5.2397995],
       [5.157366 ],
       [5.051047 ],
       [5.8220107]
```