

4.) Build three classifiers (logistic, KNN, neural net) for the Wisconsin breast cancer data set

(https://scikit-learn.org/stable/datasets/toy_dataset.html)

And then use an ensemble method to combine the three predictors. Determine the accuracy and AUC for each method alone and then for the ensemble. Use SHAP to explain what the ensemble is doing.

Turn in a notebook showing this

```
In [1]: from sklearn.datasets import load_breast_cancer  
data = load_breast_cancer()  
  
In [5]: list(data.target_names)  
Out[5]: ['malignant', 'benign']  
  
In [6]: import pandas as pd  
import numpy as np  
import matplotlib.pyplot as plt  
  
In [7]: data.keys()  
Out[7]: dict_keys(['data', 'target', 'frame', 'target_names', 'DESCR', 'feature_names', 'filename', 'data_module'])  
In [8]: X=data.data  
  
In [9]: data.feature_names  
Out[9]: array(['mean radius', 'mean texture', 'mean perimeter', 'mean area',  
       'mean smoothness', 'mean compactness', 'mean concavity',  
       'mean concave points', 'mean symmetry', 'mean fractal dimension',  
       'radius error', 'texture error', 'perimeter error', 'area error',  
       'smoothness error', 'compactness error', 'concavity error',  
       'concave points error', 'symmetry error',  
       'fractal dimension error', 'worst radius', 'worst texture',  
       'worst perimeter', 'worst area', 'worst smoothness',  
       'worst compactness', 'worst concavity', 'worst concave points',  
       'worst symmetry', 'worst fractal dimension'], dtype='<U23')  
In [10]: y=data.target
```

Nural Net

```
In [15]: from sklearn.neural_network import MLPClassifier  
clf = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, batch_size=int(min(200,  
clf.fit(X, y)
```

```
Iteration 1, loss = 12.08760684
Iteration 2, loss = 9.11703601
Iteration 3, loss = 8.41092312
Iteration 4, loss = 7.74197887
Iteration 5, loss = 7.06935370
Iteration 6, loss = 5.89548259
Iteration 7, loss = 5.00092453
Iteration 8, loss = 4.09719920
Iteration 9, loss = 3.27987110
Iteration 10, loss = 2.65784461
Iteration 11, loss = 1.99870944
Iteration 12, loss = 1.47442610
Iteration 13, loss = 1.05003995
Iteration 14, loss = 0.76221798
Iteration 15, loss = 0.62428151
Iteration 16, loss = 0.46398279
Iteration 17, loss = 0.39621035
Iteration 18, loss = 0.34337458
Iteration 19, loss = 0.33018723
Iteration 20, loss = 0.30425916
Iteration 21, loss = 0.30478458
Iteration 22, loss = 0.29303265
Iteration 23, loss = 0.29091977
Iteration 24, loss = 0.29448245
Iteration 25, loss = 0.28713521
Iteration 26, loss = 0.28744732
Iteration 27, loss = 0.27176965
Iteration 28, loss = 0.27096705
Iteration 29, loss = 0.26108145
Iteration 30, loss = 0.25977290
Iteration 31, loss = 0.25869470
Iteration 32, loss = 0.25422461
Iteration 33, loss = 0.25194349
Iteration 34, loss = 0.26121167
Iteration 35, loss = 0.25991313
Iteration 36, loss = 0.25581365
Iteration 37, loss = 0.25152765
Iteration 38, loss = 0.25004147
Iteration 39, loss = 0.25171503
Iteration 40, loss = 0.27379771
Iteration 41, loss = 0.23923649
Iteration 42, loss = 0.23628718
Iteration 43, loss = 0.23520446
Iteration 44, loss = 0.23203555
Iteration 45, loss = 0.23053361
Iteration 46, loss = 0.23191520
Iteration 47, loss = 0.22807538
Iteration 48, loss = 0.22629438
Iteration 49, loss = 0.22598447
Iteration 50, loss = 0.22560869
Iteration 51, loss = 0.22595457
Iteration 52, loss = 0.24761969
Iteration 53, loss = 0.24828246
Iteration 54, loss = 0.23222199
Iteration 55, loss = 0.23042639
Iteration 56, loss = 0.22083596
Iteration 57, loss = 0.22300536
Iteration 58, loss = 0.21916363
Iteration 59, loss = 0.22726889
Iteration 60, loss = 0.21835983
```

```
Iteration 61, loss = 0.21790401
Iteration 62, loss = 0.21919034
Iteration 63, loss = 0.22380697
Iteration 64, loss = 0.20709957
Iteration 65, loss = 0.22137600
Iteration 66, loss = 0.21424618
Iteration 67, loss = 0.24662750
Iteration 68, loss = 0.21200895
Iteration 69, loss = 0.21561917
Iteration 70, loss = 0.22757298
Iteration 71, loss = 0.21809940
Iteration 72, loss = 0.21269148
Iteration 73, loss = 0.20689578
Iteration 74, loss = 0.22045865
Iteration 75, loss = 0.21121154
Iteration 76, loss = 0.20933539
Iteration 77, loss = 0.20405688
Iteration 78, loss = 0.20164152
Iteration 79, loss = 0.19756331
Iteration 80, loss = 0.20411336
Iteration 81, loss = 0.20792991
Iteration 82, loss = 0.19340987
Iteration 83, loss = 0.19761281
Iteration 84, loss = 0.19501160
Iteration 85, loss = 0.19305371
Iteration 86, loss = 0.19287538
Iteration 87, loss = 0.19105545
Iteration 88, loss = 0.19744528
Iteration 89, loss = 0.19366096
Iteration 90, loss = 0.19136402
Iteration 91, loss = 0.20301062
Iteration 92, loss = 0.21922315
Iteration 93, loss = 0.22113739
Iteration 94, loss = 0.21921166
Iteration 95, loss = 0.20474040
Iteration 96, loss = 0.19195415
Iteration 97, loss = 0.22274788
Iteration 98, loss = 0.18602729
Iteration 99, loss = 0.19208733
Iteration 100, loss = 0.19210138
Iteration 101, loss = 0.18900590
Iteration 102, loss = 0.18914226
Iteration 103, loss = 0.19320233
Iteration 104, loss = 0.19363439
Iteration 105, loss = 0.18503315
Iteration 106, loss = 0.18294616
Iteration 107, loss = 0.17996746
Iteration 108, loss = 0.18941902
Iteration 109, loss = 0.19414312
Iteration 110, loss = 0.18507565
Iteration 111, loss = 0.17760168
Iteration 112, loss = 0.18575015
Iteration 113, loss = 0.17916573
Iteration 114, loss = 0.17884861
Iteration 115, loss = 0.17657783
Iteration 116, loss = 0.18009941
Iteration 117, loss = 0.17895938
Iteration 118, loss = 0.17604531
Iteration 119, loss = 0.17344066
Iteration 120, loss = 0.18162242
```

```
Iteration 121, loss = 0.17902350
Iteration 122, loss = 0.18965508
Iteration 123, loss = 0.17601404
Iteration 124, loss = 0.17046866
Iteration 125, loss = 0.17025996
Iteration 126, loss = 0.17469748
Iteration 127, loss = 0.19095934
Iteration 128, loss = 0.18985421
Iteration 129, loss = 0.18889614
Iteration 130, loss = 0.19010195
Iteration 131, loss = 0.18113201
Iteration 132, loss = 0.17526742
Iteration 133, loss = 0.18228073
Iteration 134, loss = 0.17368541
Iteration 135, loss = 0.18397411
Iteration 136, loss = 0.20651009
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Stopping.
```

Out[15]:

```
▼ MLPClassifier
MLPClassifier(alpha=1e-05, batch_size=100, hidden_layer_sizes=(13, 6),
               max_iter=500, random_state=1, verbose=True)
```

KNN

In [16]:

```
from sklearn.neighbors import KNeighborsClassifier
KNNclf = KNeighborsClassifier(n_neighbors=2, weights='uniform', p=1)

clf.fit(X, y)
```

```
Iteration 1, loss = 12.08760684
Iteration 2, loss = 9.11703601
Iteration 3, loss = 8.41092312
Iteration 4, loss = 7.74197887
Iteration 5, loss = 7.06935370
Iteration 6, loss = 5.89548259
Iteration 7, loss = 5.00092453
Iteration 8, loss = 4.09719920
Iteration 9, loss = 3.27987110
Iteration 10, loss = 2.65784461
Iteration 11, loss = 1.99870944
Iteration 12, loss = 1.47442610
Iteration 13, loss = 1.05003995
Iteration 14, loss = 0.76221798
Iteration 15, loss = 0.62428151
Iteration 16, loss = 0.46398279
Iteration 17, loss = 0.39621035
Iteration 18, loss = 0.34337458
Iteration 19, loss = 0.33018723
Iteration 20, loss = 0.30425916
Iteration 21, loss = 0.30478458
Iteration 22, loss = 0.29303265
Iteration 23, loss = 0.29091977
Iteration 24, loss = 0.29448245
Iteration 25, loss = 0.28713521
Iteration 26, loss = 0.28744732
Iteration 27, loss = 0.27176965
Iteration 28, loss = 0.27096705
Iteration 29, loss = 0.26108145
Iteration 30, loss = 0.25977290
Iteration 31, loss = 0.25869470
Iteration 32, loss = 0.25422461
Iteration 33, loss = 0.25194349
Iteration 34, loss = 0.26121167
Iteration 35, loss = 0.25991313
Iteration 36, loss = 0.25581365
Iteration 37, loss = 0.25152765
Iteration 38, loss = 0.25004147
Iteration 39, loss = 0.25171503
Iteration 40, loss = 0.27379771
Iteration 41, loss = 0.23923649
Iteration 42, loss = 0.23628718
Iteration 43, loss = 0.23520446
Iteration 44, loss = 0.23203555
Iteration 45, loss = 0.23053361
Iteration 46, loss = 0.23191520
Iteration 47, loss = 0.22807538
Iteration 48, loss = 0.22629438
Iteration 49, loss = 0.22598447
Iteration 50, loss = 0.22560869
Iteration 51, loss = 0.22595457
Iteration 52, loss = 0.24761969
Iteration 53, loss = 0.24828246
Iteration 54, loss = 0.23222199
Iteration 55, loss = 0.23042639
Iteration 56, loss = 0.22083596
Iteration 57, loss = 0.22300536
Iteration 58, loss = 0.21916363
Iteration 59, loss = 0.22726889
Iteration 60, loss = 0.21835983
```

```
Iteration 61, loss = 0.21790401
Iteration 62, loss = 0.21919034
Iteration 63, loss = 0.22380697
Iteration 64, loss = 0.20709957
Iteration 65, loss = 0.22137600
Iteration 66, loss = 0.21424618
Iteration 67, loss = 0.24662750
Iteration 68, loss = 0.21200895
Iteration 69, loss = 0.21561917
Iteration 70, loss = 0.22757298
Iteration 71, loss = 0.21809940
Iteration 72, loss = 0.21269148
Iteration 73, loss = 0.20689578
Iteration 74, loss = 0.22045865
Iteration 75, loss = 0.21121154
Iteration 76, loss = 0.20933539
Iteration 77, loss = 0.20405688
Iteration 78, loss = 0.20164152
Iteration 79, loss = 0.19756331
Iteration 80, loss = 0.20411336
Iteration 81, loss = 0.20792991
Iteration 82, loss = 0.19340987
Iteration 83, loss = 0.19761281
Iteration 84, loss = 0.19501160
Iteration 85, loss = 0.19305371
Iteration 86, loss = 0.19287538
Iteration 87, loss = 0.19105545
Iteration 88, loss = 0.19744528
Iteration 89, loss = 0.19366096
Iteration 90, loss = 0.19136402
Iteration 91, loss = 0.20301062
Iteration 92, loss = 0.21922315
Iteration 93, loss = 0.22113739
Iteration 94, loss = 0.21921166
Iteration 95, loss = 0.20474040
Iteration 96, loss = 0.19195415
Iteration 97, loss = 0.22274788
Iteration 98, loss = 0.18602729
Iteration 99, loss = 0.19208733
Iteration 100, loss = 0.19210138
Iteration 101, loss = 0.18900590
Iteration 102, loss = 0.18914226
Iteration 103, loss = 0.19320233
Iteration 104, loss = 0.19363439
Iteration 105, loss = 0.18503315
Iteration 106, loss = 0.18294616
Iteration 107, loss = 0.17996746
Iteration 108, loss = 0.18941902
Iteration 109, loss = 0.19414312
Iteration 110, loss = 0.18507565
Iteration 111, loss = 0.17760168
Iteration 112, loss = 0.18575015
Iteration 113, loss = 0.17916573
Iteration 114, loss = 0.17884861
Iteration 115, loss = 0.17657783
Iteration 116, loss = 0.18009941
Iteration 117, loss = 0.17895938
Iteration 118, loss = 0.17604531
Iteration 119, loss = 0.17344066
Iteration 120, loss = 0.18162242
```

```

Iteration 121, loss = 0.17902350
Iteration 122, loss = 0.18965508
Iteration 123, loss = 0.17601404
Iteration 124, loss = 0.17046866
Iteration 125, loss = 0.17025996
Iteration 126, loss = 0.17469748
Iteration 127, loss = 0.19095934
Iteration 128, loss = 0.18985421
Iteration 129, loss = 0.18889614
Iteration 130, loss = 0.19010195
Iteration 131, loss = 0.18113201
Iteration 132, loss = 0.17526742
Iteration 133, loss = 0.18228073
Iteration 134, loss = 0.17368541
Iteration 135, loss = 0.18397411
Iteration 136, loss = 0.20651009
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs. Stopping.

```

Out[16]: ▾ MLPClassifier

```
MLPClassifier(alpha=1e-05, batch_size=100, hidden_layer_sizes=(13, 6),
max_iter=500, random_state=1, verbose=True)
```

logistic

In [20]:

```
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import VotingClassifier
```

In [21]:

```
clf_ML = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, max_iter=4000, hidder
clf_neigh = KNeighborsClassifier(n_neighbors=2)

log_clf = LogisticRegression(max_iter=3000)
```

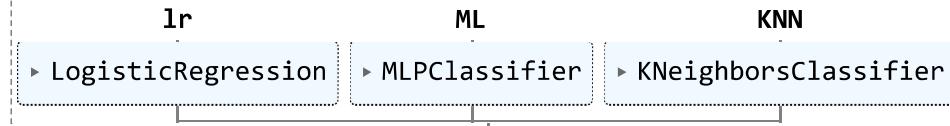
Hard Voting

In [22]:

```
voting_clf = VotingClassifier(
    estimators=[('lr', log_clf), ('ML', clf_ML), ('KNN', clf_neigh)],
    voting='hard')

voting_clf.fit(X, y)
```

Out[22]: ▾ VotingClassifier



In [23]:

```
from sklearn.metrics import accuracy_score
for clf in (log_clf, clf_neigh, clf_ML, voting_clf):
    clf.fit(X, y)
    y_pred = clf.predict(X)
    print(clf.__class__.__name__, accuracy_score(y, y_pred))
```

```
LogisticRegression 0.9578207381370826  
KNeighborsClassifier 0.968365553602812  
MLPClassifier 0.9244288224956063  
VotingClassifier 0.961335676625659
```

Soft Voting

```
In [24]: voting_clf2 = VotingClassifier(  
    estimators=[('lr', log_clf), ('ML', clf_ML), ('KNN', clf_neigh)],  
    voting='soft')
```

In [27]: y

```
In [33]: from sklearn import metrics
         from sklearn.metrics import roc_auc_score
         for clf in (log_clf, clf_neigh, clf_ML, voting_clf2):
             clf.fit(X, y)
             y_pred = clf.predict(X)
             print(clf.__class__.__name__, "The accuary : ",accuracy_score(y, y_pred), "The AUC
```

```
LogisticRegression The accucary : 0.9578207381370826 The AUC 0.9520175994926273  
KNeighborsClassifier The accucary : 0.968365553602812 The AUC 0.9747899159663865  
MLPClassifier The accucary : 0.9244288224956063 The AUC 0.9119959304476508  
VotingClassifier The accucary : 0.9648506151142355 The AUC 0.9566619100470377
```

accuracy and AUC

```
In [34]: !pip install shap
```

```
Collecting shap
  Downloading shap-0.45.0-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_64.manylinux_2_17_x86_64.manylinux2014_x86_64.whl (538 kB)
  ━━━━━━━━━━━━━━━━ 538.2/538.2 kB 5.5 MB/s eta 0:00:00
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from shap) (1.25.2)
Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages (from shap) (1.11.4)
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.10/dist-packages (from shap) (1.2.2)
Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages (from shap) (1.5.3)
Requirement already satisfied: tqdm>=4.27.0 in /usr/local/lib/python3.10/dist-packages (from shap) (4.66.2)
Requirement already satisfied: packaging>20.9 in /usr/local/lib/python3.10/dist-packages (from shap) (24.0)
Collecting slicer==0.0.7 (from shap)
  Downloading slicer-0.0.7-py3-none-any.whl (14 kB)
Requirement already satisfied: numba in /usr/local/lib/python3.10/dist-packages (from shap) (0.58.1)
Requirement already satisfied: cloudpickle in /usr/local/lib/python3.10/dist-packages (from shap) (2.2.1)
Requirement already satisfied: llvmlite<0.42,>=0.41.0dev0 in /usr/local/lib/python3.10/dist-packages (from numba->shap) (0.41.1)
Requirement already satisfied: python-dateutil>=2.8.1 in /usr/local/lib/python3.10/dist-packages (from pandas->shap) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas->shap) (2023.4)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn->shap) (1.3.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn->shap) (3.3.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.1->pandas->shap) (1.16.0)
Installing collected packages: slicer, shap
Successfully installed shap-0.45.0 slicer-0.0.7
```

```
In [35]: # ipywidgets
!pip install ipywidgets

# this will allow the notebook to reload/refresh automatically within the runtime
%reload_ext autoreload
%autoreload 2

import ipywidgets
```

```
Requirement already satisfied: ipywidgets in /usr/local/lib/python3.10/dist-packages  
(7.7.1)  
Requirement already satisfied: ipykernel>=4.5.1 in /usr/local/lib/python3.10/dist-pac  
kages (from ipywidgets) (5.5.6)  
Requirement already satisfied: ipython-genutils~0.2.0 in /usr/local/lib/python3.10/d  
ist-packages (from ipywidgets) (0.2.0)  
Requirement already satisfied: traitlets>=4.3.1 in /usr/local/lib/python3.10/dist-pac  
kages (from ipywidgets) (5.7.1)  
Requirement already satisfied: widgetsnbextension~=3.6.0 in /usr/local/lib/python3.1  
0/dist-packages (from ipywidgets) (3.6.6)  
Requirement already satisfied: ipython>=4.0.0 in /usr/local/lib/python3.10/dist-pac  
kages (from ipywidgets) (7.34.0)  
Requirement already satisfied: jupyterlab-widgets>=1.0.0 in /usr/local/lib/python3.1  
0/dist-packages (from ipywidgets) (3.0.10)  
Requirement already satisfied: jupyter-client in /usr/local/lib/python3.10/dist-pac  
kages (from ipykernel>=4.5.1->ipywidgets) (6.1.12)  
Requirement already satisfied: tornado>=4.2 in /usr/local/lib/python3.10/dist-package  
s (from ipykernel>=4.5.1->ipywidgets) (6.3.3)  
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.10/dist-pac  
kages (from ipython>=4.0.0->ipywidgets) (67.7.2)  
Collecting jedi>=0.16 (from ipython>=4.0.0->ipywidgets)  
  Downloading jedi-0.19.1-py2.py3-none-any.whl (1.6 MB)  
 _____ 1.6/1.6 MB 9.7 MB/s eta 0:00:00  
Requirement already satisfied: decorator in /usr/local/lib/python3.10/dist-packages  
(from ipython>=4.0.0->ipywidgets) (4.4.2)  
Requirement already satisfied: pickleshare in /usr/local/lib/python3.10/dist-packages  
(from ipython>=4.0.0->ipywidgets) (0.7.5)  
Requirement already satisfied: prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0 in /usr/l  
ocal/lib/python3.10/dist-packages (from ipython>=4.0.0->ipywidgets) (3.0.43)  
Requirement already satisfied: pygments in /usr/local/lib/python3.10/dist-packages (f  
rom ipython>=4.0.0->ipywidgets) (2.16.1)  
Requirement already satisfied: backcall in /usr/local/lib/python3.10/dist-packages (f  
rom ipython>=4.0.0->ipywidgets) (0.2.0)  
Requirement already satisfied: matplotlib-inline in /usr/local/lib/python3.10/dist-pa  
ckages (from ipython>=4.0.0->ipywidgets) (0.1.6)  
Requirement already satisfied: pexpect>4.3 in /usr/local/lib/python3.10/dist-pac  
kages (from ipython>=4.0.0->ipywidgets) (4.9.0)  
Requirement already satisfied: notebook>=4.4.1 in /usr/local/lib/python3.10/dist-pac  
kages (from widgetsnbextension~=3.6.0->ipywidgets) (6.5.5)  
Requirement already satisfied: parso<0.9.0,>=0.8.3 in /usr/local/lib/python3.10/dist-  
packages (from jedi>=0.16->ipython>=4.0.0->ipywidgets) (0.8.3)  
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (fro  
m notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (3.1.3)  
Requirement already satisfied: pyzmq<25,>=17 in /usr/local/lib/python3.10/dist-pac  
kages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (23.2.1)  
Requirement already satisfied: argon2-cffi in /usr/local/lib/python3.10/dist-packages  
(from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (23.1.0)  
Requirement already satisfied: jupyter-core>=4.6.1 in /usr/local/lib/python3.10/dist-  
packages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (5.7.2)  
Requirement already satisfied: nbformat in /usr/local/lib/python3.10/dist-packages (f  
rom notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (5.10.2)  
Requirement already satisfied: nbconvert>=5 in /usr/local/lib/python3.10/dist-pac  
kages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (6.5.4)  
Requirement already satisfied: nest-asyncio>=1.5 in /usr/local/lib/python3.10/dist-pa  
ckages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.6.0)  
Requirement already satisfied: Send2Trash>=1.8.0 in /usr/local/lib/python3.10/dist-pa  
ckages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.8.2)  
Requirement already satisfied: terminado>=0.8.3 in /usr/local/lib/python3.10/dist-pac  
kages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.18.1)  
Requirement already satisfied: prometheus-client in /usr/local/lib/python3.10/dist-pa
```

```
ckages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.20.0)
Requirement already satisfied: nbclassic>=0.4.7 in /usr/local/lib/python3.10/dist-pac
kages (from notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.0.0)
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.10/dist
-packages (from jupyter-client->ipykernel>=4.5.1->ipywidgets) (2.8.2)
Requirement already satisfied: ptyprocess>=0.5 in /usr/local/lib/python3.10/dist-pack
ages (from pexpect>4.3->ipython>=4.0.0->ipywidgets) (0.7.0)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.10/dist-packages (fr
om prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0->ipython>=4.0.0->ipywidgets) (0.2.13)
Requirement already satisfied: platformdirs>=2.5 in /usr/local/lib/python3.10/dist-pa
ckages (from jupyter-core>=4.6.1->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidg
ets) (4.2.0)
Requirement already satisfied: jupyter-server>=1.8 in /usr/local/lib/python3.10/dist-
packages (from nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidge
ts) (1.24.0)
Requirement already satisfied: notebook-shim>=0.2.3 in /usr/local/lib/python3.10/dist
-packages (from nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidg
ets) (0.2.4)
Requirement already satisfied: lxml in /usr/local/lib/python3.10/dist-packages (from
nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (4.9.4)
Requirement already satisfied: beautifulsoup4 in /usr/local/lib/python3.10/dist-pac
kages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (4.1
2.3)
Requirement already satisfied: bleach in /usr/local/lib/python3.10/dist-packages (fro
m nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (6.1.0)
Requirement already satisfied: defusedxml in /usr/local/lib/python3.10/dist-packages
(from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.7.1)
Requirement already satisfied: entrypoints>=0.2.2 in /usr/local/lib/python3.10/dist-p
ackages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets)
(0.4)
Requirement already satisfied: jupyterlab-pygments in /usr/local/lib/python3.10/dist-
packages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets)
(0.3.0)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-pac
kages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (2.
1.5)
Requirement already satisfied: mistune<2,>=0.8.1 in /usr/local/lib/python3.10/dist-pa
ckages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets)
(0.8.4)
Requirement already satisfied: nbclient>=0.5.0 in /usr/local/lib/python3.10/dist-pac
kages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.1
0.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages
(from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (24.0)
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/lib/python3.10/dist
-packages (from nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets)
(1.5.1)
Requirement already satisfied: tinycss2 in /usr/local/lib/python3.10/dist-packages (f
rom nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.2.1)
Requirement already satisfied: fastjsonschema in /usr/local/lib/python3.10/dist-pac
kages (from nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (2.19.1)
Requirement already satisfied: jsonschema>=2.6 in /usr/local/lib/python3.10/dist-pac
kages (from nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (4.19.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (f
rom python-dateutil>=2.1->jupyter-client->ipykernel>=4.5.1->ipywidgets) (1.16.0)
Requirement already satisfied: argon2-cffi-bindings in /usr/local/lib/python3.10/dist
-packages (from argon2-cffi->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets)
(21.2.0)
Requirement already satisfied: attrs>=22.2.0 in /usr/local/lib/python3.10/dist-pac
kages (from jsonschema>=2.6->nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywi
```

```
dgets) (23.2.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (2023.12.1)
Requirement already satisfied: referencing>=0.28.4 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.33.0)
Requirement already satisfied: rpds-py>=0.7.1 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.18.0)
Requirement already satisfied: anyio<4,>=3.1.0 in /usr/local/lib/python3.10/dist-packages (from jupyter-server>=1.8->nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (3.7.1)
Requirement already satisfied: websocket-client in /usr/local/lib/python3.10/dist-packages (from jupyter-server>=1.8->nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.7.0)
Requirement already satisfied: cffi>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from argon2-cffi-bindings->argon2-cffi->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.16.0)
Requirement already satisfied: soupsieve>1.2 in /usr/local/lib/python3.10/dist-packages (from beautifulsoup4->nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (2.5)
Requirement already satisfied: webencodings in /usr/local/lib/python3.10/dist-packages (from bleach->nbconvert>=5->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (0.5.1)
Requirement already satisfied: idna>=2.8 in /usr/local/lib/python3.10/dist-packages (from anyio<4,>=3.1.0->jupyter-server>=1.8->nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (3.6)
Requirement already satisfied: sniffio>=1.1 in /usr/local/lib/python3.10/dist-packages (from anyio<4,>=3.1.0->jupyter-server>=1.8->nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.3.1)
Requirement already satisfied: exceptiongroup in /usr/local/lib/python3.10/dist-packages (from anyio<4,>=3.1.0->jupyter-server>=1.8->nbclassic>=0.4.7->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (1.2.0)
Requirement already satisfied: pycparser in /usr/local/lib/python3.10/dist-packages (from cffi>=1.0.1->argon2-cffi-bindings->argon2-cffi->notebook>=4.4.1->widgetsnbextension~=3.6.0->ipywidgets) (2.21)
Installing collected packages: jedi
Successfully installed jedi-0.19.1
```

```
In [36]: import shap
```

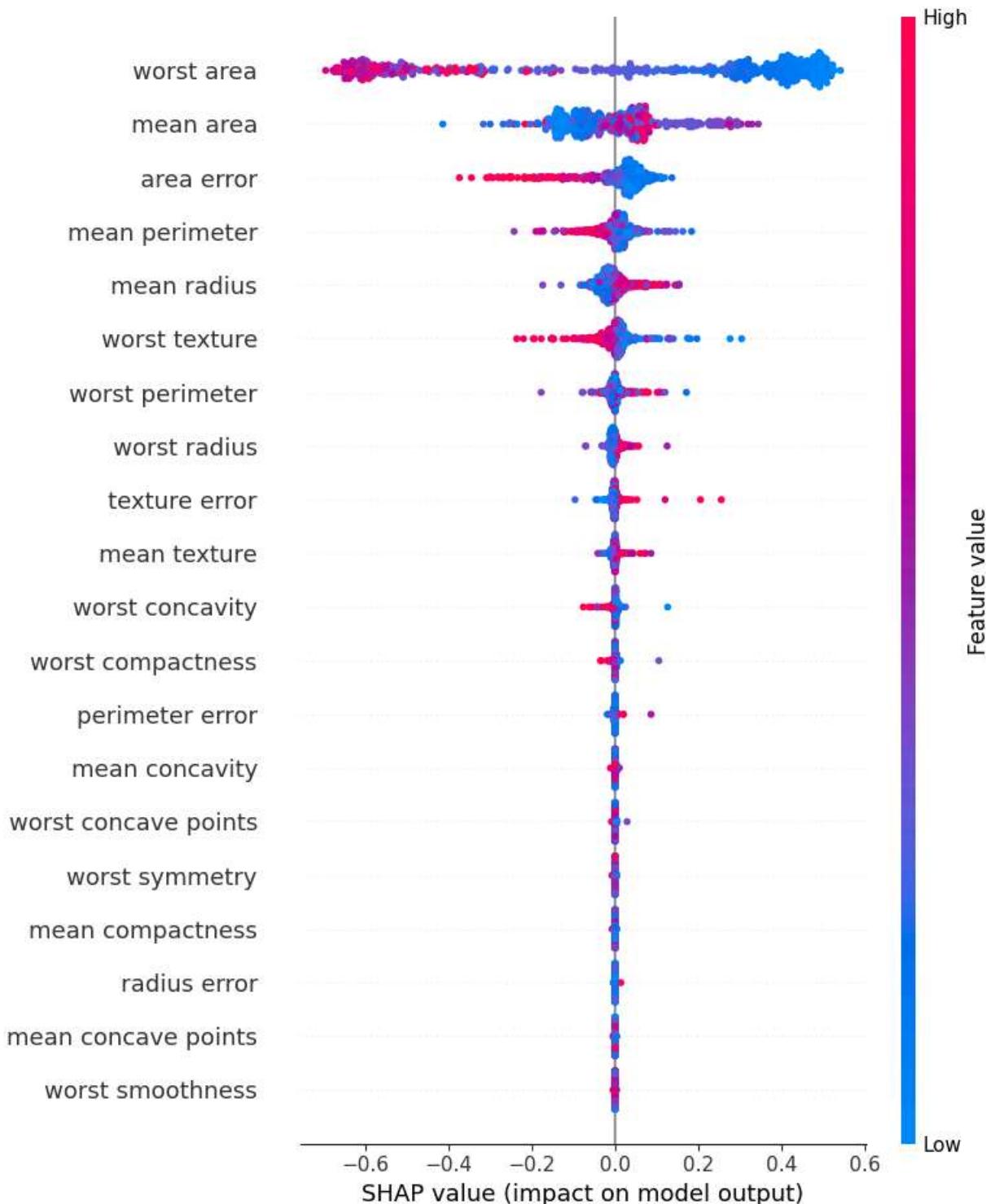
```
In [37]: explainer = shap.PermutationExplainer(voting_clf2.predict,X)
```

```
In [38]: shap_values = explainer.shap_values(X)
```

```
PermutationExplainer explainer: 570it [03:49,  2.41it/s]
```

```
In [40]: import matplotlib.pyplot as plt
fig=plt.figure(figsize=(10,10))

shap.summary_plot(shap_values,X,feature_names=data.feature_names)
```



for the top 3 features that impact the model: Low "worst area" and "area error" values increases shap value while high value decrease shap value. Mean area seems to have the opposite effect.

In []: