ECSE 551 Group 5 Mini-Project 1

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Abstract

In this project, logistic regression was utilized to address two binary classification problems: the white wine quality and the blood in kidney datasets. The study commenced by developing simple models to establish baseline results, which were then improved by conducting various experiments. To arrive at the best set of features, we used feature importance to build our models with the best set of features. Removing the least important feature (Heart rate) in the kidney disease dataset yielded better results. All features were needed in the white wine datasets to build the best model. Some other techniques that enhanced the accuracy of models are log transformation, second and third order of features. Overall, the logistic regression model findings indicate that these modifications can improve the accuracy and robustness of the model for both datasets.

1 Introduction

Logistic regression is a powerful machine-learning tool for performing binary classification tasks. The algorithm uses an iterative optimization algorithm, such as gradient descent, to estimate the coefficients or weights of the model. Using the logistic function to convert the estimated log-odds ratio of a given class, which is derived as a linear combination of features, we can predict the probability of a particular outcome based on input data [1]. This report applies logistic regression to two classification tasks: predicting the presence of blood in a patient's kidney based on their medical history and assessing the quality of white wine based on certain characteristics.

To create the most effective models for these tasks, the datasets are analyzed, feature engineering is performed, and the optimization algorithm parameters are carefully considered. It is crucial to understand the data set to build an accurate machine learning model [2]. Section 2 describes the datasets in detail. It describes how we used the feature importance technique [3] to select the best set of features. This technique is used to evaluate the relationship between features and class labels. We also demonstrate the distribution of features in both datasets and applied log-transformation if needed. To test the performance of the model with higher complexity, we also add different order of parameters to the model.

The effectiveness of different feature engineering techniques is evaluated in Section 3, with analysis of the influence of several optimization parameters on model performance, including tolerance, learning rate, and initial weights. A 10-fold cross-validation approach is employed to determine the most effective models, based on the highest accuracy obtained [4]. Furthermore, the number of iterations required for the optimization algorithm to converge is determined by examining the point at which additional iterations no longer result in significant decreases in the cost function [5].. Finally, in Section 4, the report summarizes the key findings and suggests areas for future research. Overall, this report demonstrates the importance of understanding the data and carefully optimizing machine learning models to achieve the best possible results in binary classification tasks.

After training the models, we found that the best learning rate in both datasets is $\frac{1}{k+1}$ where k is the

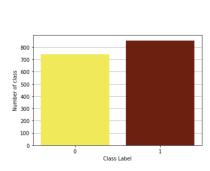
iteration number. The best ϵ for the kidney disease dataset is 10^{-6} , while for the white wine quality dataset, the best $\epsilon = 10^{-5}$. Removing the least important feature (Heart rate) in the kidney disease dataset yielded better results. All features were needed in the white wine datasets to build the best model. In the white wine dataset, the log of Total phenols and Proanthocyanins has the best accuracy. In the kidney disease dataset, the log of Insulin and Age has the best accuracy.

2 Datasets

Before applying logistic regression to a dataset, it is crucial to analyze the data thoroughly.

2.1 White Wine Quality

This data set contains 1599 samples and ten features. These features include Alcohol, Malic acid, Ash, Alkalinity of ash, Magnesium, Total phenols, Flavanoids, Nonflavanoid phenols, Proanthocyanins, and Hue. We double-check to see that all features have been standardized to provide normalized values. The class label of the white wine data set is a crucial element in determining the quality of wine, with a score of 1 being assigned to wines of high quality and 0 assigned to wines of low quality. By examining the dataset, we found that it consists of 855 samples of high-quality wines and 744 samples of low-quality wines. This distribution is plotted in Figure 1.



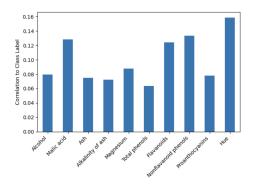


Figure 1: Distribution of class labels in white wine dataset

Figure 2: Importance of each feature to the class label in the white wine dataset

No outliers existed in the dataset. It also did not have any null values. By checking for duplicate rows, we found 244 duplicate row in white wine dataset. We depicted the correlation of features to the class label in Figure 2 using Feature Importance. Most features are almost dependent on the class label. However, Total phenols and Alkalinity of ash have the least correlation to the class label. For this reason, removing these independent features from the logistic regression is more reasonable. This process is explained in more detail in Section 3.5.

We demonstrated the distributions of the features of white wine dataset in Figure 3. It would be desirable if all the features were normally distributed and had similar scales. However, some features such as Ash, Alkalinity of ash and Total phenols have skewed distributions. To enhance the performance of the model, a log-transformation that would normalize these features could be employed [6]. This process in explained in Section 3.4.

There exist multiple techniques for determining the optimal approach to selecting features to include, exclude, scale or multiply to produce the most effective model. Other than Feature Importance technique, Mutual Information [7] or Correlation-based Feature Selection [8] can also be named. We demonstrated the correlation between features in Figure 4. It would be cautious about identifying which features have a high degree of correlation to each other. Keeping just one of them may be sufficient in cases with a significant correlation between features. Utilizing all correlated features could result in overfitting, which would ultimately reduce the accuracy[9]. Some features such as Ash and Alcohol are highly correlated. We consider removing highly correlated features and training different models with them.

2.2 Blood in Kidney

The blood in kidney dataset contains medical information, with 330 inputs and nine unique features used as predictor variables. These features include Pregnancies (number of times pregnant), Glucose

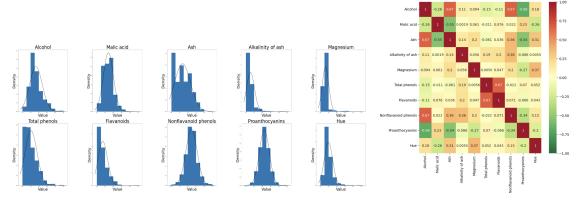


Figure 3: Distribution of white wine features

Figure 4: Correlation between white wine features

(plasma glucose concentration after a 2-hour oral glucose tolerance test), Blood Pressure (diastolic blood pressure in mm Hg), Heart Rate, Skin Thickness (triceps skin fold thickness in mm), Insulin (2-hour serum insulin in mu U/ml), BMI (body mass index), Diabetes Pedigree Function, and Age (in years).

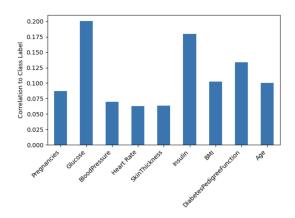


Figure 5: Importance of each feature to the class label in the blood in kidney dataset

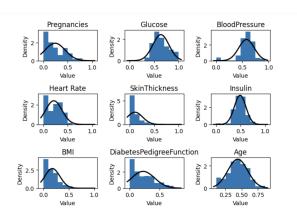


Figure 6: Distribution of blood in kidney features

In blood in kidney dataset, out of the 330 inputs, 165 have a class label of 1, indicating the presence of blood, while the other 165 have a class label of 0, indicating the absence of blood. No outliers existed in the dataset. It also did not have any null values. The kidney disease dataset also did not have any duplicate rows.

We have taken a page from our analysis of the white wine quality dataset and looked at the correlation between the features and class labels, which is plotted in Figure 5. As discussed earlier, we are exploring the possibility of removing independent features to improve the model's accuracy. We understand that some features like Heartrate, SkinThickness and BloodPressure have the least correlation to class labels.

In Figure 6, we have also plotted the distribution of the features in the dataset. Interestingly, some of the features, like SkinThickness and BMI, do not have a normalized distribution. This is taken into consideration as our logistic regression classification model is being fine-tuned.

In both datasets, we consider building models with higher complexity of features and training those models. Different combinations and orders of features are tested in section 3.6

3 Results

The proposed logistic regression model is built based on five functions. The fit function is utilized to determine the weights by performing gradient descent when working with a training dataset. A

predict function to anticipate outcomes using a validation dataset. The sigmoid function takes any real value and maps it between 0 and 1. the accu_eval function compares the anticipated results with the actual data. Finally, the calculate loss function calculates the model's cross-entropy loss.

The logistic regression's performance is evaluated using a standard 10-fold cross-validation method. During each training, multiple values are stored. The learning rate, the epsilon, the number of iterations required for convergence, the elapsed time for the training, the model weights and whether or not the maximum number of iterations was reached during training. The model's accuracy is also calculated as the mean accuracy of the folds in k-fold validation.

3.1 Shuffling the data

It was found that both the white wine dataset and the kidney disease dataset are ordered by the class label. If the data is not shuffled, it would lead to validation/training sets with only one class of data. Therefore, it is necessary to shuffle the rows of the dataset once it is read. This not only prevents overfitting and reduces variance but also helps to generalize the algorithm.

3.2 Learning rate

To find out the best learning rates, different variables are tested. These include independent variables (constant numbers like 1/8) and variables dependent on other parameters. For example, k is the iteration number inside the while loop in our fit function, and n is the number of samples. The performance of all these learning rates on both datasets is presented in table 1. The model failed to converge in a reasonable amount of iterations for constant learning rates for the white wine dataset. The only constant learning rate with acceptable performance in the kidney disease dataset is 0.01. However, the best learning rate for both datasets is $\frac{1}{1+k}$. While having the highest accuracy, it still holds an acceptable iteration count. If the learning rate is too small the model will take a long time to converge, and the training may get stuck in a suboptimal solution, never reaching the global minimum. On the other hand, if the learning rate is too large, the model may oscillate forever.

Learning rate	Learning rate type	White wine		Kidney disease	
		Iteration count	Accuracy%	Iteration count	Accuracy%
0.01	Constant	150000	failed	956	0.7495
1/2	Constant	150000	failed	150000	0.6832
1/4	Constant	150000	failed	150000	0.6835
1/8	Constant	150000	failed	150000	0.6832
0.05	Constant	150000	failed	150000	0.6885
1/k	dependent	4032	0.7350	2220	0.7510
1/(k+1)	dependent	2753	0.7381	1476	0.7520
1/n	dependent	1362	0.7292	2048	0.7495
1/10n	dependent	74	0.5366	3516	0.7414
1/100n	dependent	2	0.5351	2	0.5168

Table 1: The performance of different learning rates on both datasets.

3.3 Stopping Condition

The weights for this project are trained until the difference between the current weight vector and the previous weight vector, denoted as $||w_k - w_{k-1}||$, is less than the tolerance value ϵ . In this section, different values for ϵ are experimented with, ranging from 10^{-2} to 10^{-9} . The training result is demonstrated in Table 2. Due to the page limitations, the table is summarized. But, the full model configurations for each dataset are available inside the code folder. For the white wine dataset, there is only a marginal improvement in accuracy in 10^{-6} compared to 10^{-5} , which comes at the expense of a significant increase in the number of iterations. Therefore, is it more reasonable to choose 10^{-5} . For the kidney disease dataset, $\epsilon = 10^{-6}$ is chosen since it increases the accuracy by just a small cost in time and iteration number.

3.4 Log Transformation

As discussed in Section 2, some features have skewed distributions, and standardization can help improve their distribution. To address this issue, one solution is to transform these features into distributions that resemble a Gaussian distribution by taking the logarithm of their values [10]. An experiment was conducted to examine the impact of a log transformation on the accuracy of the

Epsilon -	White wine			Kidney disease		
	Iteration count	Time	Accuracy%	Iteration count	Time	Accuracy%
1e-2	235	0.138	0.7298	84	0.009	0.7370
1e-5	2753	1.104	0.7381	636	0.027	0.7495
1e-6	5496	2.174	0.7382	876	0.072	0.7515
1e-9	36990	16.286	0.7381	22164	22164	0.7508

Table 2: The performance of different epsilons on both datasets.

logistic regression model. In the white wine dataset, the log of Total phenols and Proanthocyanins have the best accuracy. In the kidney disease dataset, the log of Insulin and Age have the best accuracy.

3.5 Removing Features

We performed Feature Importance in Section 2. The results provided evidence that certain features are statistically independent to some extent from the class label. In the white wine dataset, the features that are most likely to be independent of the class label are Total phenols, Alkalinity of ash, and Ash. For the Kidney disease data set, Heart Rate and SkinThickness are most likely to be independent of the class label.

The experiment involved removing each of the potential independent features individually, as well combinations of them at once, and recording any resulting increase in accuracy. The kidney disease dataset exhibited an accuracy improvement of 1.2% when the Heartrate feature was removed. However, in the white wine dataset, the model's accuracy was not enhanced by removing any of the features.

3.6 Higher Complexity Model

When building models, it is sometimes beneficial to add the exponentiation of features to the model to improve its accuracy. This can create new dimensions and capture non-linear relationships between variables. In this project, we have performed exponentiation of features to increase the model's complexity. We have used different combination features in the datasets and recorded the model's accuracy. The best model in the white wine dataset includes the order two of alkalinity of ash and magnesium features. The most accurate model in the kidney disease dataset has the order three of the SkinThickness feature.

4 Discussion and Conclusions

In this mini-project, logistic regression was applied to two datasets with the aim of calculating the accuracy of 10-fold cross-validation. Several methods were used to improve the accuracy, including selecting important features, performing log transformation on features with non-normal distributions, and exponentiation. In conclusion, the application of these methods to logistic regression models can be useful in enhancing their performance and accuracy. However, it is important to note that the choice of method should depend on the characteristics of the dataset and the objectives of the study.

4.1 Future Investigation

As a future investigation, we could explore the use of other machine learning algorithms such as decision trees, random forests, support vector machines, or neural networks and measure their accuracy on the datasets. In addition, it is practical to study the impact of a feature selection method, like Recursive Feature Elimination on the model's accuracy. This method measures the correlation of features to the class label [11].

Another step for future investigation would be to collect external data on the similar subject and test the model's accuracy on those new data. The external dataset may include different types of noise or errors that the model has not encountered before in the cross-validation procedure. By doing so, we would be able to evaluate the generalizability of the model and investigate its accuracy.

5 Contribution Statement

Sara Yabesi: preparing the data, implementing the algorithm, evaluating the model, and preparing the report.

Mahta Amini: preparing the data, implementing the algorithm, evaluating the model, and preparing the report.

Baharan Nouriinanloo: preparing the data, implementing the algorithm, evaluating the model, and preparing the report.

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6 Appendix

Kidney_disease_analysis

February 19, 2023

```
[27]: import pandas as pd
      import numpy as np
      import matplotlib.pyplot as plt
      import seaborn as sns
      from scipy.stats import norm
[28]: from google.colab import drive
      drive.mount('/content/gdrive/', force_remount=True)
      kd_data = pd.read_csv('/content/gdrive/MyDrive/kidney_disease.csv')
      print(kd_data.shape)
     Mounted at /content/gdrive/
     (329, 10)
[29]: kd_data.columns = ['Pregnancies', 'Glucose', 'BloodPressure', 'Heart Rate', |
       SkinThickness', 'Insulin', 'BMI', 'DiabetesPedigreeFunction',
       [30]: kd_feature_names = kd_data.columns[:-1]
      kd_feature_number = len(kd_feature_names)
      kd features = kd data.iloc[:,0:-1]
      kd_data_cl_number = len(kd_data)
[31]: kd_data.describe()
[31]:
             Pregnancies
                             Glucose
                                     BloodPressure
                                                     Heart Rate
                                                                 SkinThickness
             329.000000
                         329.000000
                                         329.000000
                                                     329.000000
                                                                    329.000000
      count
      mean
                0.240837
                            0.635717
                                           0.579127
                                                       0.214301
                                                                      0.106602
      std
                0.207416
                            0.165684
                                           0.148497
                                                       0.167121
                                                                      0.156054
     min
                0.000000
                            0.000000
                                           0.000000
                                                       0.000000
                                                                      0.000000
      25%
                0.058824
                            0.512560
                                           0.524590
                                                       0.000000
                                                                      0.000000
      50%
                0.176470
                            0.613070
                                           0.590160
                                                       0.232320
                                                                      0.057920
      75%
                0.411760
                            0.738690
                                           0.655740
                                                       0.333330
                                                                      0.153660
                                           0.934430
                1.000000
                            1.000000
                                                       1.000000
                                                                      1.000000
     max
```

```
Insulin
                                 BMI
                                      DiabetesPedigreeFunction
                                                                         Age \
             329.000000 329.000000
                                                     329.000000
                                                                 329.000000
      count
      mean
               0.489131
                            0.177812
                                                       0.223759
                                                                    0.440215
      std
               0.118597
                            0.148117
                                                       0.192474
                                                                    0.153893
      min
               0.000000
                            0.000000
                                                       0.000000
                                                                    0.107690
      25%
               0.420270
                            0.075149
                                                       0.066667
                                                                    0.338460
      50%
               0.490310
                            0.132790
                                                       0.183330
                                                                    0.430770
      75%
               0.552910
                            0.246370
                                                       0.350000
                                                                    0.553850
               1.000000
                                                       0.816670
      max
                            0.961140
                                                                    0.861540
             class_label
      count
              329.000000
      mean
                0.498480
                0.500759
      std
      min
                0.000000
      25%
                0.000000
      50%
                0.000000
      75%
                1.000000
      max
                1.000000
[32]: kd_data.duplicated().sum()
      print("is duplicate:",kd_data.duplicated().sum())
      print("is null:",kd_data.isnull().values.any())
      print("maxmium values",kd_data.max(axis=0))
      print("minimum values",kd_data.min(axis=0))
     is duplicate: 0
     is null: False
     maxmium values Pregnancies
                                                  1.00000
     Glucose
                                   1.00000
     BloodPressure
                                  0.93443
     Heart Rate
                                   1.00000
     SkinThickness
                                   1.00000
     Insulin
                                   1.00000
                                  0.96114
     DiabetesPedigreeFunction
                                  0.81667
     Age
                                  0.86154
     class_label
                                   1.00000
     dtype: float64
     minimum values Pregnancies
                                                  0.00000
     Glucose
                                  0.00000
     BloodPressure
                                  0.00000
     Heart Rate
                                  0.00000
     SkinThickness
                                  0.00000
     Insulin
                                  0.00000
```

```
BMI 0.00000
DiabetesPedigreeFunction 0.00000
Age 0.10769
class_label 0.00000
dtype: float64
```

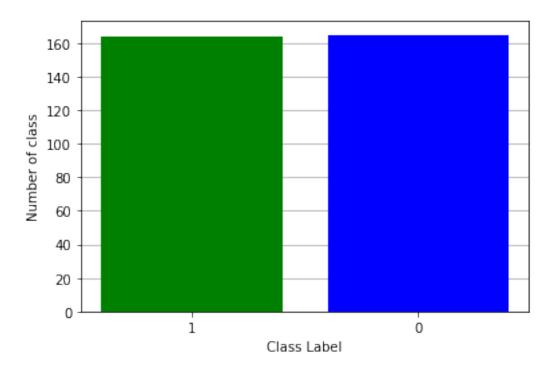
```
[33]: # distribution of class 0 and class 1
kd_label_counts = kd_data["class_label"].value_counts()
print(kd_label_counts)
unique_labels = kd_data["class_label"].unique()

fig, ax = plt.subplots()
ax.grid(zorder=1, axis="y")
ax.bar(unique_labels, kd_label_counts, zorder=2,color=['blue', 'green'])
ax.set_xticks([0,1])
ax.set_xticklabels(unique_labels)
ax.set_ylabel("Number of class")
ax.set_xlabel("Class_Label")
```

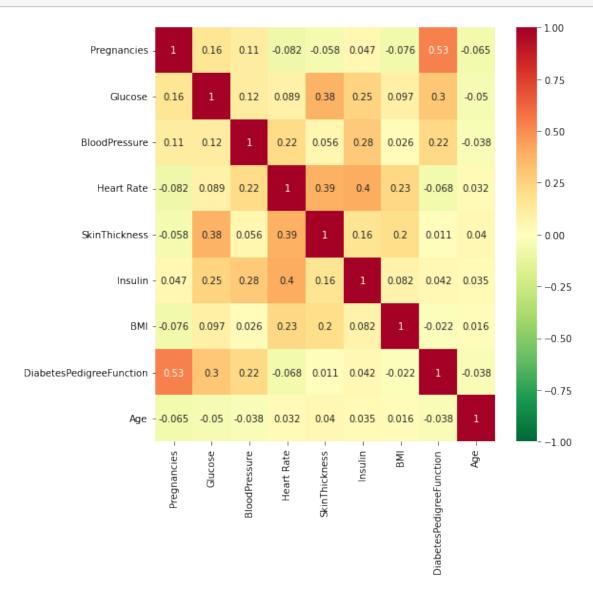
0 165 1 164

Name: class_label, dtype: int64

[33]: Text(0.5, 0, 'Class Label')



```
[34]: #draw heatmap of kidney disease
kd_corr = kd_features.corr()
plt.figure(figsize=(8,8))
sns.heatmap(kd_corr, cmap='RdYlGn_r', annot=True, vmin=-1, vmax=1)
plt.show()
```



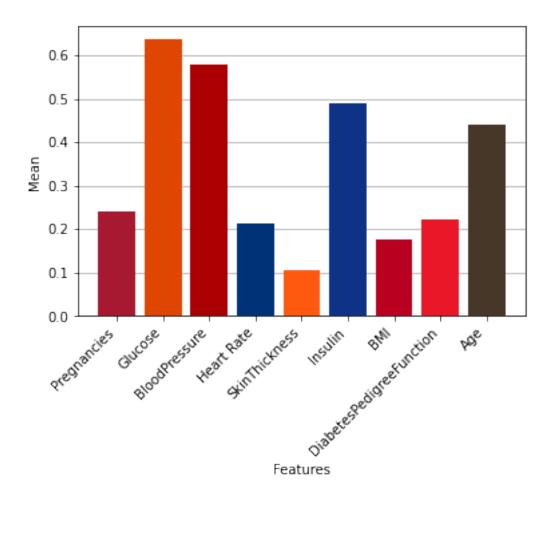
```
[35]: # Compute mean of each feature
means = kd_features.mean()

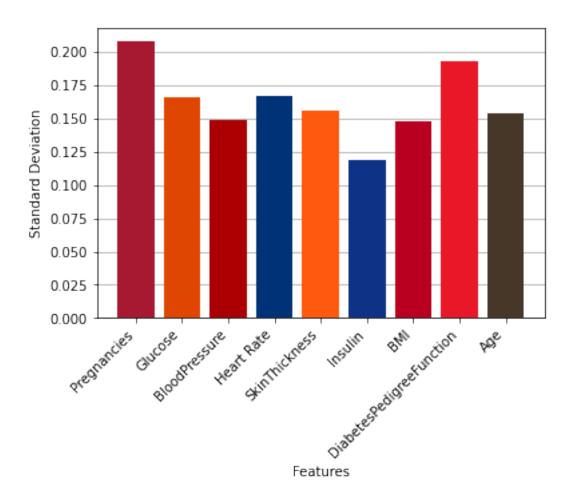
# Compute standard deviation of each feature
std = kd_features.std()

# Plot mean and standard deviation of each attribute
```

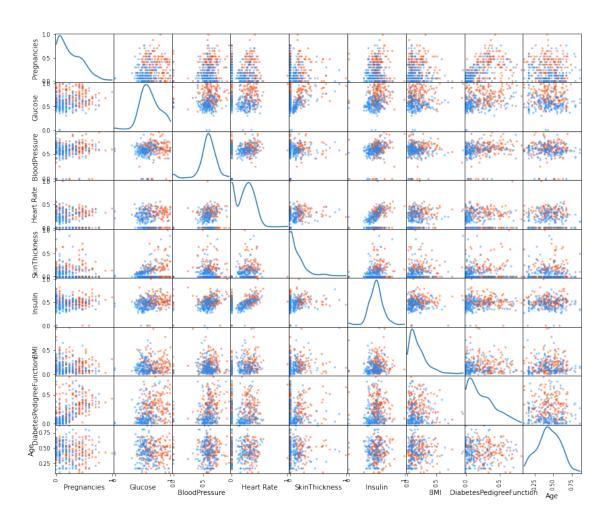
```
kd_colors=['#A71930', '#DF4601', '#AB0003', '#003278', '#FF5910', '#0E3386', |
\text{\#, '\#D31145', '\#0C2340', '\#005A9C', '\#BD3039', '\#EB6E1F', '\#C41E3A', '\#33006F', }_{\square}
↔'#C6011F', '#004687', '#CE1141', '#134A8E', '#27251F', '#FDB827', '#0C2340', □
→'#FD5A1E', '#00A3E0', '#ffc52f', '#003831', '#005C5C', '#E31937', '#8FBCE6']
fig, ax = plt.subplots()
ax.grid(zorder=1, axis="y")
ax.bar(kd_feature_names, means, zorder=2,color=kd_colors)
plt.xticks(rotation=45,ha='right')
ax.set_xlabel("Features")
ax.set_ylabel("Mean")
fig, ax = plt.subplots()
ax.grid(zorder=1, axis="y")
ax.bar(kd_feature_names, std, zorder=2,color=kd_colors)
ax.set_xlabel("Features")
plt.xticks(rotation=45,ha='right')
ax.set_ylabel("Standard Deviation")
```

[35]: Text(0, 0.5, 'Standard Deviation')



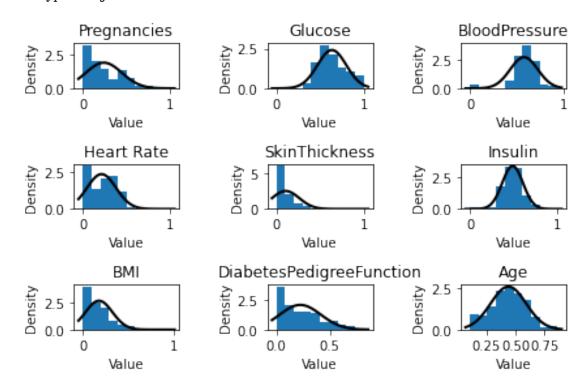


```
[36]: color = ['dodgerblue', 'orangered']
colors = kd_data['class_label'].map(lambda x: color[x])
pd.plotting.scatter_matrix(kd_features, figsize= (14, 12), diagonal='kde', u
color=colors);
```



```
[37]: #distribution of features
      def draw_distributon_graph(x_features,names):
        kd_normal_fig, axis = plt.subplots(3, 3)
        col = 0
        for x, ax in enumerate(axis.ravel()):
            ax.hist(x_features.loc[:, names[col]], density=True)
            mu, std = norm.fit(x_features.loc[:, names[col]])
            xmin, xmax = ax.get_xlim()
            x = np.linspace(xmin, xmax, 100)
            p = norm.pdf(x, mu, std)
            ax.plot(x, p, 'k', linewidth=2)
            ax.set_title(names[col])
            ax.set_xlabel("Value")
            ax.set_ylabel("Density")
            col += 1
        kd_normal_fig.tight_layout()
```

```
print(kd_feature_names)
draw_distributon_graph(kd_features,kd_feature_names)
```

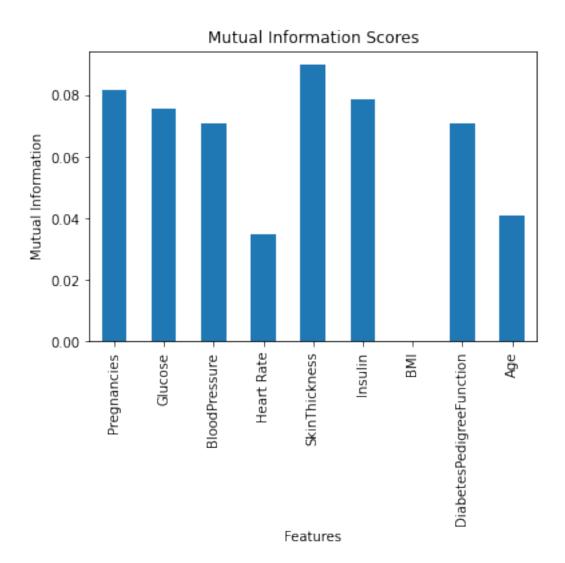


```
[38]: #mutual information
from sklearn.feature_selection import mutual_info_classif
import matplotlib.pyplot as plt

def plot_mutual_information(X, y, feature_names):
    mi_scores = mutual_info_classif(X, y)
    mi_scores_series = pd.Series(mi_scores, index=feature_names)
    mi_scores_series.plot(kind='bar')
    plt.title('Mutual Information Scores')
    plt.xlabel('Features')
    plt.ylabel('Mutual Information')
    return mi_scores_series.index.tolist()

kd_x = kd_data.drop('class_label', axis=1).to_numpy()
kd_y = kd_data.to_numpy()[:, -1].reshape(-1,1)
print(kd_x.shape)
print(kd_y.shape)
```

```
plot_mutual_information(kd_x,kd_y,kd_data.columns [:-1])
     (329, 9)
     (329, 1)
     /usr/local/lib/python3.8/dist-packages/sklearn/utils/validation.py:993:
     DataConversionWarning: A column-vector y was passed when a 1d array was
     expected. Please change the shape of y to (n_samples, ), for example using
     ravel().
       y = column_or_1d(y, warn=True)
[38]: ['Pregnancies',
       'Glucose',
       'BloodPressure',
       'Heart Rate',
       'SkinThickness',
       'Insulin',
       'BMI',
       'DiabetesPedigreeFunction',
       'Age']
```



```
[39]: #feature importance
from sklearn.ensemble import RandomForestClassifier
print(kd_features.shape)
feature_names = kd_data.columns[:-1]
print(feature_names)
y = kd_data.to_numpy()[:, -1]
print(y.shape)
forest = RandomForestClassifier(random_state=0)
forest.fit(kd_features, y)

importances = forest.feature_importances_
print(importances)
std = np.std([tree.feature_importances_ for tree in forest.estimators_], axis=0)
```

```
forest_importances = pd.Series(importances, index=feature_names)

kd_colors=['#A71930', '#DF4601', '#AB0003', '#003278', '#FF5910', '#0E3386',

'#BA0021', '#E81828', '#473729']

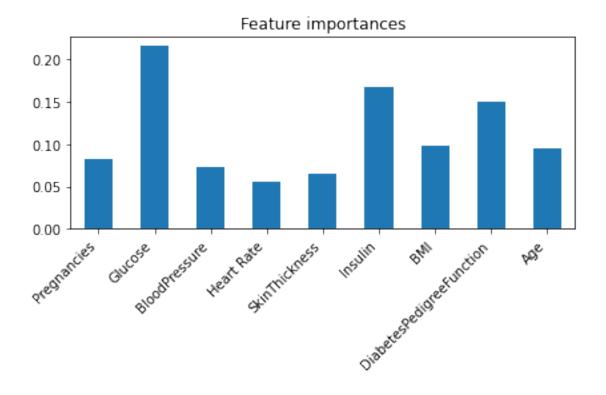
fig, ax = plt.subplots()

forest_importances.plot.bar(ax=ax)

plt.xticks(rotation=45,ha='right')

ax.set_title("Feature importances")

fig.tight_layout()
```



```
[40]: #implement RFE
from sklearn.datasets import make_friedman1
from sklearn.feature_selection import RFE
from sklearn.feature_selection import RFECV
from sklearn.svm import SVR
```

```
X = kd_features
y = kd_data.to_numpy()[:, -1]
estimator = SVR(kernel="linear")
selector = RFE(estimator, n_features_to_select=8, step=1)
selector = selector.fit(X, y)
print(selector.support_)
print(selector.ranking_)
print(importances)
print('false indices:',np.where(selector.support_ == False)[0])
falseData = np.where(selector.support_ == False)[0];
print('final false features:',X.columns[falseData])
[ True True True False True True True True]
[1 1 1 2 1 1 1 1 1]
[0.08160676 0.21521658 0.07359165 0.05590117 0.06448943 0.16692592
0.09776524 0.15017762 0.09432563]
false indices: [3]
final false features: Index(['Heart Rate'], dtype='object')
```

[40]:

White wine analysis

February 19, 2023

[52]: import pandas as pd

import numpy as np

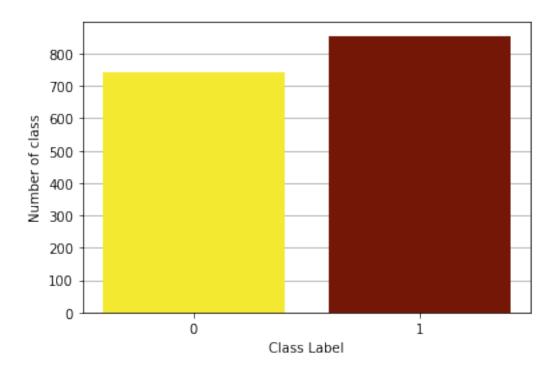
import seaborn as sns

import matplotlib.pyplot as plt

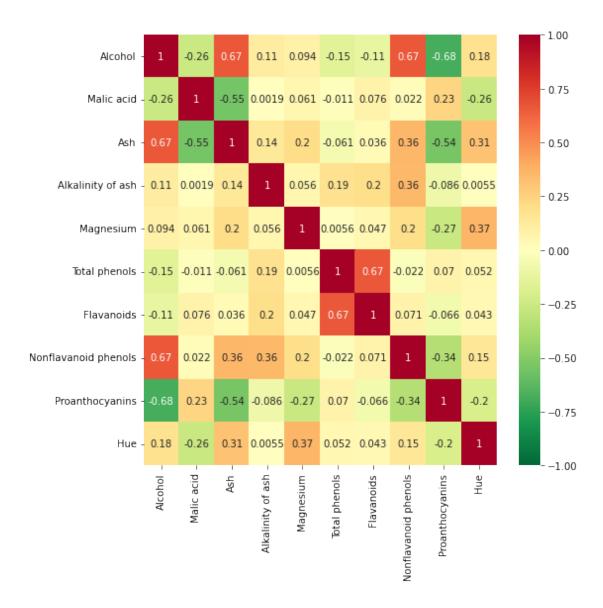
```
[53]: from google.colab import drive
     drive.mount('/content/gdrive/', force_remount=True)
     ww_columns = ['Alcohol', 'Malic acid', 'Ash', 'Alkalinity of ash', 'Magnesium', _
       ⇔'Total phenols', 'Flavanoids', 'Nonflavanoid phenols', 'Proanthocyanins', ⊔
       ww_data = pd.read csv('/content/gdrive/MyDrive/White wineQuality.csv', __
       Mounted at /content/gdrive/
[54]: ww_data.head()
[54]:
        Alcohol Malic acid
                              Ash
                                   Alkalinity of ash Magnesium Total phenols
     0 0.28319
                    0.28082 0.04
                                            0.054795
                                                      0.106840
                                                                     0.225350
                                                                     0.140850
     1 0.19469
                             0.07
                                                      0.128550
                    0.34932
                                            0.082192
     2 0.30088
                    0.20548 0.17
                                            0.075342
                                                      0.101840
                                                                     0.070423
     3 0.30088
                    0.20548
                             0.17
                                            0.075342
                                                      0.101840
                                                                     0.070423
     4 0.24779
                    0.34247 0.05
                                            0.068493
                                                      0.093489
                                                                     0.323940
        Flavanoids Nonflavanoid phenols Proanthocyanins
                                                              Hue class_label
                                 0.46442
     0
          0.088339
                                                 0.46457
                                                          0.13772
     1
          0.134280
                                 0.38371
                                                 0.57480 0.13174
                                                                             1
     2
          0.042403
                                 0.52311
                                                 0.43307
                                                                             1
                                                          0.16766
     3
          0.042403
                                 0.52311
                                                 0.43307
                                                                             1
                                                          0.16766
     4
          0.127210
                                 0.44241
                                                 0.53543 0.14371
                                                                             1
[55]: ww_data.describe()
[55]:
                          Malic acid
                Alcohol
                                              Ash Alkalinity of ash
                                                                       Magnesium \
     count
            1599.000000
                         1599.000000
                                     1599.000000
                                                        1599.000000
                                                                     1599.000000
               0.329172
                            0.279329
                                         0.270976
                                                           0.112247
                                                                        0.125987
     mean
                            0.122644
                                                           0.096570
     std
               0.154079
                                         0.194801
                                                                        0.078573
```

```
0.000000
      min
                0.000000
                              0.000000
                                            0.000000
                                                                0.000000
      25%
                0.221240
                                            0.090000
                              0.184930
                                                                0.068493
                                                                             0.096828
      50%
                0.292040
                              0.273970
                                            0.260000
                                                                0.089041
                                                                             0.111850
      75%
                0.407080
                              0.356160
                                            0.420000
                                                                0.116440
                                                                             0.130220
                1.000000
                              1.000000
                                            1.000000
                                                                1.000000
                                                                             1.000000
      max
             Total phenols
                              Flavanoids
                                           Nonflavanoid phenols Proanthocyanins
               1599.000000
                             1599.000000
                                                    1599.000000
                                                                      1599.000000
      count
                  0.209506
                                0.142996
                                                       0.489853
      mean
                                                                         0.449695
      std
                  0.147326
                                0.116238
                                                       0.138461
                                                                         0.121565
      min
                  0.000000
                                0.000000
                                                       0.000000
                                                                         0.000000
      25%
                  0.084507
                                0.056537
                                                       0.405720
                                                                         0.370080
                                                       0.490100
      50%
                  0.183100
                                0.113070
                                                                         0.448820
      75%
                  0.281690
                                0.197880
                                                       0.569700
                                                                         0.519690
                                1.000000
                                                       1.000000
                                                                         1.000000
                  1.000000
      max
                           class_label
                      Hue
             1599.000000
                           1599.000000
      count
                0.196496
                              0.534709
      mean
                0.101501
                              0.498950
      std
                0.000000
      min
                              0.000000
      25%
                              0.000000
                0.131740
      50%
                0.173650
                              1.000000
      75%
                0.239520
                              1.000000
                1.000000
      max
                              1.000000
[56]: ww_x = ww_data.drop('class_label', axis=1).to_numpy()
      ww_y = ww_data.to_numpy()[:, -1].reshape(-1,1)
      print(ww_x.shape)
      print(ww_y.shape)
     (1599, 10)
     (1599, 1)
[57]: ww_feature_names = ww_data.columns[:-1]
      ww_feature_number = len(ww_feature_names)
      ww_features = ww_data.iloc[:,0:-1]
      ww_data_cl_number = len(ww_data)
[58]: # check duplicate in rows
      ww_data.duplicated().sum()
      print("is duplicate:",ww_data.duplicated().sum())
      # check null input in rows
      print("is null:",ww_data.isnull().values.any())
      print("maxmium values", ww_data.max(axis=0))
```

```
print("minimum values", ww_data.min(axis=0))
     is duplicate: 244
     is null: False
     maxmium values Alcohol
                                             1.0
     Malic acid
                              1.0
     Ash
                              1.0
     Alkalinity of ash
                              1.0
     Magnesium
                              1.0
     Total phenols
                              1.0
     Flavanoids
                              1.0
     Nonflavanoid phenols
                              1.0
     Proanthocyanins
                              1.0
     Hue
                              1.0
     class_label
                              1.0
     dtype: float64
     minimum values Alcohol
                                             0.0
     Malic acid
                              0.0
     Ash
                              0.0
     Alkalinity of ash
                              0.0
                              0.0
     Magnesium
     Total phenols
                              0.0
     Flavanoids
                              0.0
     Nonflavanoid phenols
                              0.0
     Proanthocyanins
                              0.0
                              0.0
     Hue
                              0.0
     class_label
     dtype: float64
[59]: # distribution of class 0 and class 1
      label_counts = ww_data["class_label"].value_counts()
      print(label_counts)
      unique_labels = ww_data["class_label"].unique()
      fig, ax = plt.subplots()
      ax.grid(zorder=1, axis="y")
      ax.bar(unique_labels, label_counts, zorder=2, color=['#751706', '#f2e930'])
      ax.set_xticks([1,0])
      ax.set_xticklabels(unique_labels)
      ax.set_ylabel("Number of class")
      ax.set_xlabel("Class Label")
     1
          855
          744
     0
     Name: class_label, dtype: int64
[59]: Text(0.5, 0, 'Class Label')
```



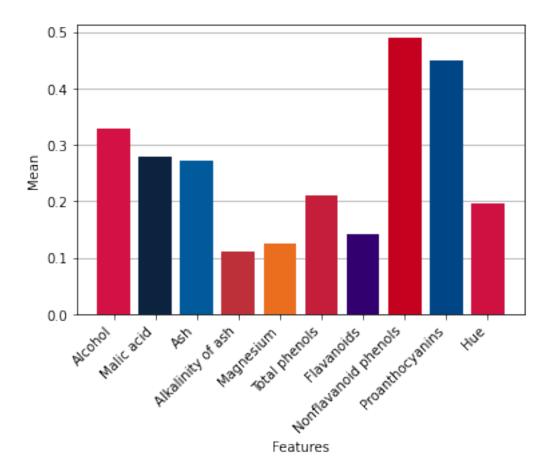
```
[60]: # correlation between features
ww_corr = ww_features.corr()
plt.figure(figsize=(8,8))
sns.heatmap(ww_corr, cmap='RdYlGn_r', annot=True, vmin=-1, vmax=1)
plt.show()
```

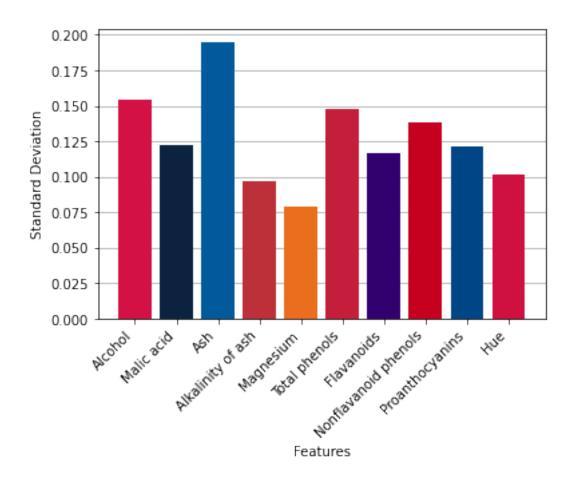


```
plt.xticks(rotation=45,ha='right')
ax.set_xlabel("Features")
ax.set_ylabel("Mean")

fig, ax = plt.subplots()
ax.grid(zorder=1, axis="y")
ax.bar(ww_feature_names, std, zorder=2, color=ww_colors)
ax.set_xlabel("Features")
plt.xticks(rotation=45,ha='right')
ax.set_ylabel("Standard Deviation")
```

[61]: Text(0, 0.5, 'Standard Deviation')



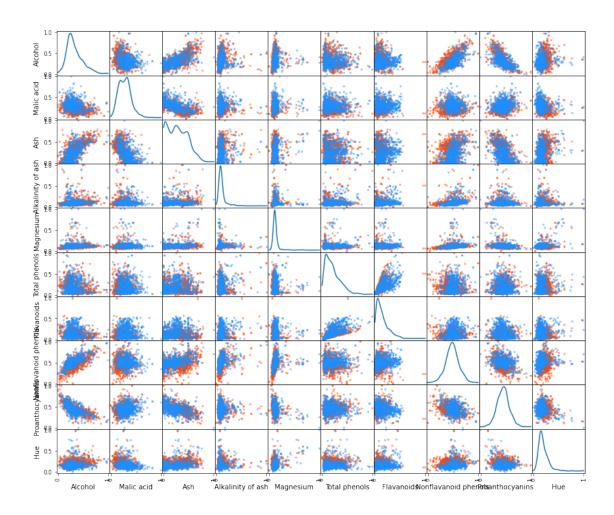


```
[62]: # correlation between features

color = ['dodgerblue', 'orangered']

colors = ww_data['class_label'].map(lambda x: color[x])

pd.plotting.scatter_matrix(ww_features, figsize= (14, 12), diagonal='kde', use color=colors);
```



```
[63]: ww_ndata = ww_data.to_numpy()
print(np.min(ww_ndata))
print(np.max(ww_ndata))
```

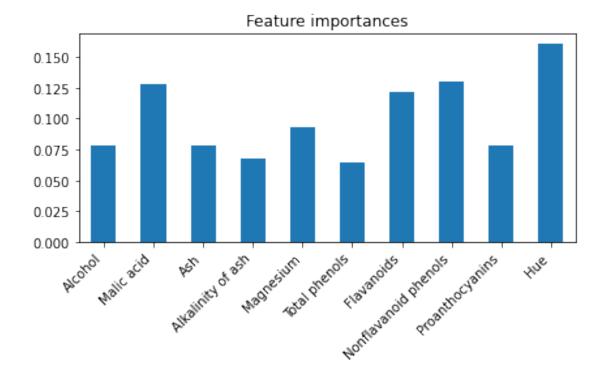
0.0

```
[68]: from sklearn.ensemble import RandomForestClassifier

feature_names = ww_data.columns[:-1]
  print(feature_names)
  y = ww_data.to_numpy()[:, -1]
  forest = RandomForestClassifier(random_state=0)
  forest.fit(ww_features, y)

importances = forest.feature_importances_
  print(importances)
std = np.std([tree.feature_importances_ for tree in forest.estimators_], axis=0)
```

```
forest_importances = pd.Series(importances, index=feature_names)
fig, ax = plt.subplots()
forest_importances.plot.bar(ax=ax)
#forest_importances.sort_values(ascending=False).plot.bar(ax=ax)
plt.xticks(rotation=45,ha='right')
ax.set_title("Feature importances")
fig.tight_layout()
```



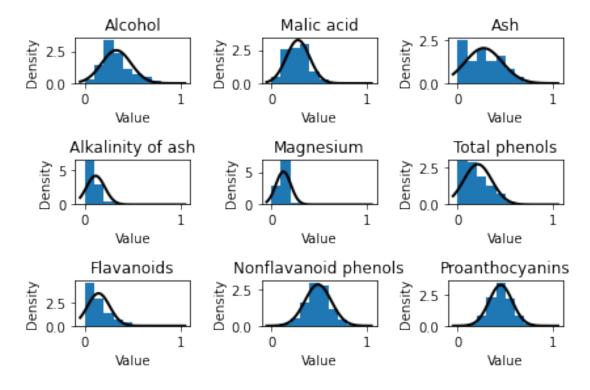
```
[65]: from scipy.stats import norm

def draw_distributon_graph(x_features,names):
    kd_normal_fig, axis = plt.subplots(3, 3)
    col = 0

for x, ax in enumerate(axis.ravel()):
    ax.hist(x_features.loc[:, names[col]], density=True)
```

```
mu, std = norm.fit(x_features.loc[:, names[col]])
    xmin, xmax = ax.get_xlim()
    x = np.linspace(xmin, xmax, 100)
    p = norm.pdf(x, mu, std)
    ax.plot(x, p, 'k', linewidth=2)
    ax.set_title(names[col])
    ax.set_xlabel("Value")
    ax.set_ylabel("Density")
    col += 1
    kd_normal_fig.tight_layout()

print(ww_feature_names)
    draw_distributon_graph(ww_features, ww_feature_names)
```



```
[66]: #impelementation of RFE
from sklearn.datasets import make_friedman1
from sklearn.feature_selection import RFE
from sklearn.feature_selection import RFECV
from sklearn.svm import SVR
```

```
X = ww_features
y = ww_data.to_numpy()[:, -1]
estimator = SVR(kernel="linear")
selector = RFE(estimator, n_features_to_select=9, step=1)
selector = selector.fit(X, y)
print(selector.support_)

print(selector.ranking_)

estimator2 = SVR(kernel="linear")
selector2 = RFECV(estimator2, step=1, cv=5,min_features_to_select = 9)
selector2 = selector.fit(X, y)
print('2',selector2.support_)

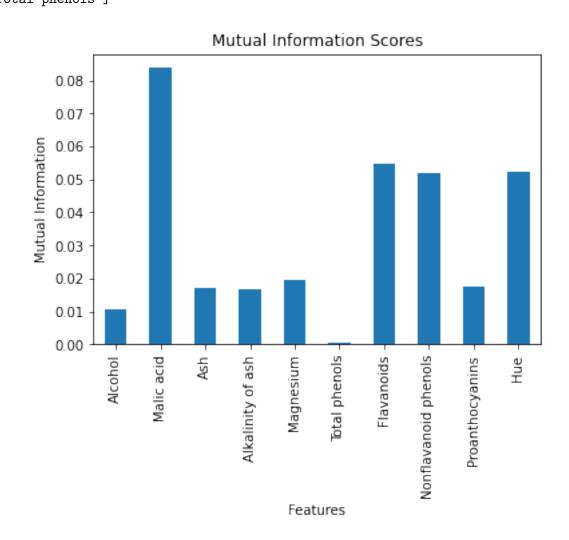
print('2',selector2.ranking_)
```

[True True False True True True True True True]
[1 1 2 1 1 1 1 1 1]
2 [True True False True True True True True True]
2 [1 1 2 1 1 1 1 1 1]

```
[67]: #plot mutual information
      from sklearn.feature_selection import mutual_info_classif
      import matplotlib.pyplot as plt
      from sklearn.feature_selection import mutual_info_classif
      import matplotlib.pyplot as plt
      import numpy as np
      def plot_mutual_information(X, y, feature_names):
          np.random.seed(4)
          mi_scores = mutual_info_classif(X, y)
          mi_scores_series = pd.Series(mi_scores, index=feature_names)
          mi_scores_series.plot(kind='bar')
          plt.title('Mutual Information Scores')
          plt.xlabel('Features')
          plt.ylabel('Mutual Information')
          return mi_scores_series.sort_values(ascending=False).index.tolist()
      plot_mutual_information(ww_x,ww_y,ww_columns[:-1])
```

/usr/local/lib/python3.8/dist-packages/sklearn/utils/validation.py:993: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().

```
y = column_or_1d(y, warn=True)
```



kidney_disease_model

February 19, 2023

```
[2]: import pandas as pd
    import numpy as np
    import matplotlib.pyplot as plt
    import seaborn as sns
    from scipy.stats import norm
    from google.colab import drive
    import random
    import time
    from enum import Enum
    from sklearn.preprocessing import StandardScaler
    drive.mount('/content/gdrive/', force_remount=True)
    kd_columns = ['Pregnancies', 'Glucose', 'BloodPressure', 'Heart Rate', |
     →'SkinThickness', 'Insulin', 'BMI', 'DiabetesPedigreeFunction', □
     kd_data_initial = pd.read_csv('/content/gdrive/MyDrive/kidney_disease.csv',_
     →names = kd_columns )
    print(kd_data_initial.shape)
    ww_columns = ['Alcohol', 'Malic acid', 'Ash', 'Alkalinity of ash', 'Magnesium', _
     ⇔'Total phenols', 'Flavanoids', 'Nonflavanoid phenols', 'Proanthocyanins', ⊔
     ww data initial = pd.read_csv('/content/gdrive/MyDrive/white_wine_quality.
     ⇔csv',names = ww_columns)
    print(ww_data_initial.shape)
    Mounted at /content/gdrive/
    (330, 10)
    (1599, 11)
[3]: def shuffle_data(df):
        random.seed(0) # Use a fixed seed for the random number generator
        df = df.sample(frac=1, random_state=0).reset_index(drop=True)
        return df
```

```
[4]: kd_data = shuffle_data(kd_data_initial)
    ww_data = shuffle_data(ww_data_initial)
[5]: #get feature columns and lable column and convert it to array
    kd_x = kd_data.drop('class_label', axis=1).to_numpy()
    kd_y = kd_data.to_numpy()[:, -1].reshape(-1,1)
    ww_x = ww_data.drop('class_label', axis=1).to_numpy()
    ww_y = ww_data.to_numpy()[:, -1].reshape(-1,1)
[6]: #defined a dataframe for storing the result of model, an enum for different
     ⇔learning types
    model_data = pd.
      -DataFrame(columns=['model_name','description','learning_rate','iteration','weights','epsilo

    'is_max_reached','loss','accuracy_kfold','variable'])

    learning_rate_type = Enum('lr_type', ['independent', 'iteration', __
      [7]: #utility functions
    def train_test_split(x, y, train_size=0.8):
        num_rows = x.shape[0]
        num_rows_train = int(num_rows * train_size )
        num_rows_test = num_rows - num_rows_train
        x_train = x[:num_rows_train, :]
        x_test = x[num_rows_train:, :]
        y_train = y[:num_rows_train]
        y_test = y[num_rows_train:]
        return x_train, y_train, x_test, y_test
     #convert feature to Gaussian distribution
    def log_transform_normalize(df, index):
        df_copy = df.copy()
        df_copy.iloc[:, index] = df_copy.iloc[:, index].apply(lambda x: np.nan if x_
      \Rightarrow <= 0 else x)
        #add small values to avoid NaN
        df_copy.iloc[:, index] = np.log(df_copy.iloc[:, index] + 1e-10)
        mean_val = df_copy.iloc[:, index].mean()
        df_copy.iloc[:, index] = df_copy.iloc[:, index].fillna(mean_val)
        scaler = StandardScaler()
        df_copy.iloc[:, index] = scaler.fit_transform(df_copy.iloc[:, index].values.
      \hookrightarrowreshape(-1, 1))
```

```
[8]: class Logistic_Regression:
         def __init__(self, learning_rate , learning_rate_type , max_iterations ,_
      ⇔epsilon):
             self.x = []
             self.y = []
             self.weights = []
             self.learning_rate = learning_rate
             self.learning_rate_type = learning_rate_type
             self.max_iterations = max_iterations
             self.epsilon = epsilon
         def fit(self,x, y,is_add_bias = False):
             self.x = x;
             self.y = y;
             loss list = []
             t_start = time.time()
             n, m = self.x.shape
             is_max_reached = False
             #add bias/dummy feature
             #initialize weights with zero
             if(is_add_bias == True):
               bias = np.ones((n,1), dtype=np.double)
               self.x = np.append(self.x, bias, axis = 1)
               self.weights = np.zeros(((m+1),1))
             else:
               self.weights = np.zeros(((m),1))
             #define initial norm value
             norm_weights = 1e8
             iteration = 1
             while (iteration < self.max_iterations) & (norm_weights > self.epsilon):
               #if(iteration\%10000 == 0):
```

```
#print('iteration number:',iteration)
        if(self.learning_rate_type == learning_rate_type.iteration):
             self.learning_rate = (1/ iteration)
        elif(self.learning_rate_type == learning_rate_type.
→iteration_plus_one):
             self.learning_rate = (1/ (1 + iteration))
        elif(self.learning_rate_type == learning_rate_type.sample_size):
             self.learning_rate = (1/(1 + n))
        elif(self.learning_rate_type == learning_rate_type.ten_sample_size):
             self.learning_rate = (1/(10 * n))
        elif(self.learning_rate_type == learning_rate_type.
⇔hundred_sample_size):
            self.learning_rate = (1/(100 * n))
        #if(iteration == 15):
          # print("learning rate type:",self.learning_rate_type)
          # print("learning rate:",self.learning_rate)
        if iteration % 100 == 0:
          loss_model = self.cross_entropy_loss(self.x, self.y);
          loss_list.append((iteration, loss_model))
        # Store current weights before updating
        weight_previous = self.weights
        # Compute gradient
        gradient = np.sum(
        self.x * (self.y - self.sigmoid(np.dot(self.x, weight_previous))),__
⊶axis=0
        ).reshape(-1, 1)
        # Update weights
        self.weights = weight_previous + self.learning_rate * gradient
        # Compute change in weights
        norm_weights = np.linalg.norm(self.weights - weight_previous) ** 2
        iteration += 1
       if(iteration == self.max iterations):
       print (f"*********failed to reach minimum in {self.
→max_iterations iterations")
       is_max_reached = True
      t_end = time.time()
```

```
#time elapsed for model training
    elapsed_time = round(t_end - t_start,3)
   return iteration, self.weights, elapsed_time, is_max_reached, loss_list
 # Decision boundary(threshold)
def predict(self):
  decision boundary = 0.5
 y_predict = self.sigmoid(np.dot(self.x, self.weights))
 y_pred = np.where(y_predict < decision_boundary, 0, 1)</pre>
 return y_pred
#compute accuracy of model
def accu_eval(self, y_pred):
  accuracy = np.count_nonzero(self.y == y_pred) / len(self.y)
 return accuracy
def sigmoid(self, arg):
   return 1 / (1 + np.exp(-arg))
#compute cross entropy loss
def cross_entropy_loss(self, x_data, y_data):
   y_pred_0 = self.sigmoid(np.dot(x_data,self.weights))
   y_pred_1 = 1 - y_pred_0
   # Replace small values to avoid NAN (log0)
   y_pred_0 = np.where(y_pred_0 < 1e-6, 1e-6, y_pred_0)
   y_pred_1 = np.where(y_pred_1 < 1e-6, 1e-6, y_pred_1)</pre>
   loss_0 = y_data * np.log(y_pred_0)
   loss_1 = (1-y_data) * np.log(y_pred_1)
   loss = -np.sum(loss_0 + loss_1)
   return loss
```

```
# Split data
   i_start = partition_size * i
   i_end = partition_size*(i+1)
   if i != (k-1):
     x_train_fold = np.concatenate((x_train_initial[:i_start,:],__

¬x_train_initial[i_end:,:]),axis=0)
     y_train_fold = np.concatenate((y_train_initial[:i_start,:],__
⇔y_train_initial[i_end:,:]),axis=0)
     x_validation_fold = x_train_initial[i_start:i_end,:]
     y_validation_fold = y_train_initial[i_start:i_end,:]
   else:
     # For final partition
     x_train_fold = lgr_model.x[:i_start,:]
     y_train_fold = lgr_model.y[:i_start,:]
     x_validation_fold = lgr_model.x[i_start:,:]
     y_validation_fold = lgr_model.y[i_start:,:]
   iteration, weight_store , epalsed_time_one , is_max_reached , loss_list =_{\sqcup}
→lgr_model.fit(x_train_fold,y_train_fold,False)
   y_predict = lgr_model.predict()
   model_accuracy = lgr_model.accu_eval(y_predict)
   model_accuracy_list.append(model_accuracy)
   cross_entropy = lgr_model.

¬cross_entropy_loss(x_validation_fold,y_validation_fold)

   model loss list.append(cross entropy)
   #print("model_accuracy:",model_accuracy)
   #return model accuracy
 return np.mean(model_accuracy_list),np.mean(model_loss_list)
\hookrightarrow it in model data
```

```
[10]: #define a function that gets the weights and runs k-fold algorithm, then stores
it in model data

def run_model(model_name , description, learning_rate , learning_rate_type,
max_iterations , epsilon, x_train , y_train , model_data , variable):

model = Logistic_Regression(learning_rate = learning_rate, learning_rate_type
= learning_rate_type , max_iterations = max_iterations, epsilon = epsilon)
model_iteration_num , model_weights , model_elapsed_time ,
is_max_iteration_reached, loss_list = model.fit(x_train,y_train, True)
```

```
model_accuracy_kfold,model_loss_kfold = kfold_cross_validation(model,_
       ⇒k=10,x_train_initial = model.x , y_train_initial = model.y)
        final learning rate = model.learning rate if learning rate type ==___
       Glearning_rate_type.independent else learning_rate_type
        model_data = model_data.append({'model_name':model_name,'description':
       description, 'learning_rate' : final_learning_rate,
                                         'iteration' : model_iteration_num, 'weights' : __
       →model weights, 'epsilon': model.epsilon,
                                         'elapsed_time':model_elapsed_time,_

    'is_max_reached': is_max_iteration_reached, 'loss':model_loss_kfold,
                                     'accuracy kfold':model accuracy kfold , ,

¬'variable':variable}, ignore_index = True)

        return model data
[11]: kd_x_train, kd_y_train, kd_x_test, kd_y_test = train_test_split(kd_x,kd_y,1)
      print(kd_x_train.shape)
      print(kd_y_train.shape)
      ww_x_train, ww_y_train, ww_x_test, ww_y_test = train_test_split(ww_x,ww_y,1)
     (330, 9)
     (330, 1)
[12]: #function sort dataframe by accuracy and delete dataframe
      def show_sorted_model(data):
       return data.sort_values(by=['accuracy_kfold'], ascending=False)
      def delete_model(data):
        return data.drop(model_data.index,inplace=True)
      def delete_last_model(data,number):
        return data.drop(data.tail(number).index,inplace=True)
[13]: #delete_model(model_data)
      show sorted model(model data)
      #print(kd_x_train.shape)
      #delete_model(model_data)
[13]: Empty DataFrame
      Columns: [model name, description, learning rate, iteration, weights, epsilon,
      elapsed_time, is_max_reached, loss, accuracy_kfold, variable]
      Index: []
[14]: #train whole model
      model_data = run_model('kd','whole model',learning_rate = 0.01,__
       -learning rate_type = learning rate_type.independent ,max_iterations = 150000,
```

```
epsilon = 1e-6,x_train = kd_x_train , y_train =_

¬kd_y_train , model_data = model_data, variable = 'all features')

     show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[14]: model_name description learning_rate iteration \
               kd whole model
                                        0.01
                                                   956
                                                 weights
                                                           epsilon elapsed_time \
     0 [[2.5819277747484066], [6.780007402086465], [-... 0.000001
                                                                        0.049
                            loss accuracy_kfold
       is_max_reached
                                                     variable
                                       0.749495 all features
                False 15.855793
[15]: #explore different constant learning rates
     learning_rates = [1/2, 1/4, 1/8, 0.05]
     for i in range(len(learning_rates)):
       title = 'whole model-lr:' + str(learning_rates[i])
       model_data = run_model('kd',title,learning_rate = learning_rates[i],__
       -learning_rate_type = learning_rate_type.independent ,max_iterations = 150000,
                            epsilon = 1e-6,x_train = kd_x_train , y_train =
       →kd_y_train , model_data = model_data,variable = 'learning rate')
     show_sorted_model(model_data)
     ********failed to reach minimum in 150000 iterations
     i====> 0
     *************failed to reach minimum in 150000 iterations
     i====> 1
     *********failed to reach minimum in 150000 iterations
     i====> 2
     *********failed to reach minimum in 150000 iterations
     i====> 3
     **********failed to reach minimum in 150000 iterations
     i====> 4
     *************failed to reach minimum in 150000 iterations
     i====> 5
     **********failed to reach minimum in 150000 iterations
```

```
i====> 6
*********failed to reach minimum in 150000 iterations
i====> 7
*********failed to reach minimum in 150000 iterations
i====> 8
**********failed to reach minimum in 150000 iterations
i====> 9
*************failed to reach minimum in 150000 iterations
**********failed to reach minimum in 150000 iterations
i====> 0
*********failed to reach minimum in 150000 iterations
i====> 1
*********failed to reach minimum in 150000 iterations
i====> 2
*********failed to reach minimum in 150000 iterations
i====> 3
*********failed to reach minimum in 150000 iterations
i====> 4
*********failed to reach minimum in 150000 iterations
i====> 5
**********failed to reach minimum in 150000 iterations
i====> 6
*************failed to reach minimum in 150000 iterations
i====> 7
************failed to reach minimum in 150000 iterations
i====> 8
*************failed to reach minimum in 150000 iterations
i====> 9
************failed to reach minimum in 150000 iterations
*********failed to reach minimum in 150000 iterations
i====> 0
*********failed to reach minimum in 150000 iterations
i====> 1
*********failed to reach minimum in 150000 iterations
i====> 2
**********failed to reach minimum in 150000 iterations
i====> 3
*************failed to reach minimum in 150000 iterations
i====> 4
*********failed to reach minimum in 150000 iterations
i====> 5
*************failed to reach minimum in 150000 iterations
i====> 6
*************failed to reach minimum in 150000 iterations
i====> 7
*********failed to reach minimum in 150000 iterations
i====> 8
**********failed to reach minimum in 150000 iterations
```

```
i====> 9
     *********failed to reach minimum in 150000 iterations
     *********failed to reach minimum in 150000 iterations
     i====> 0
     *********failed to reach minimum in 150000 iterations
     i====> 1
     **********failed to reach minimum in 150000 iterations
     i====> 2
     **********failed to reach minimum in 150000 iterations
     i====> 3
     *********failed to reach minimum in 150000 iterations
     i====> 4
     *********failed to reach minimum in 150000 iterations
     i====> 5
     *********failed to reach minimum in 150000 iterations
     *********failed to reach minimum in 150000 iterations
     i====> 7
     *********failed to reach minimum in 150000 iterations
     i====> 8
     **********failed to reach minimum in 150000 iterations
     i====> 9
     *************failed to reach minimum in 150000 iterations
[15]:
       model_name
                            description learning_rate iteration
     0
               kd
                            whole model
                                                0.010
                                                            956
     4
               kd
                    whole model-lr:0.05
                                                0.050
                                                         150000
                    whole model-lr:0.25
     2
               kd
                                                0.250
                                                         150000
     1
               kd
                     whole model-lr:0.5
                                                0.500
                                                         150000
     3
               kd whole model-lr:0.125
                                                0.125
                                                         150000
                                                 weights
                                                           epsilon elapsed_time \
     0 [[2.5819277747484066], [6.780007402086465], [-... 0.000001
                                                                         0.049
     4 [[9.970728371948313], [26.491694165903258], [-... 0.000001
                                                                         6.472
     2 [[47.64433276868854], [130.6790054571249], [-1... 0.000001
                                                                         6.500
     1 [[95.81933692733199], [262.7825656994754], [-3... 0.000001
                                                                         8.592
     3 [[24.070810464619214], [65.46666343519061], [-... 0.000001
                                                                         8.383
       is_max_reached
                                  accuracy_kfold
                                                       variable
                             loss
                False
                        15.855793
                                        0.749495
                                                   all features
     0
     4
                 True
                        46.838322
                                        0.688552 learning rate
     2
                 True 106.221172
                                        0.683502 learning rate
     1
                 True 118.189617
                                        0.683165 learning rate
     3
                 True
                       87.970034
                                        0.683165 learning rate
[16]: #explore different dependent learning rates
```

```
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
```

```
i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[16]:
       model_name
                                                   description \
                     whole model-lr:lr_type.iteration_plus_one
                kd
      5
                kd
                              whole model-lr:lr_type.iteration
      0
                kd
                                                    whole model
      7
                kd
                            whole model-lr:lr_type.sample_size
      8
                kd
                        whole model-lr:lr_type.ten_sample_size
      4
                kd
                                           whole model-lr:0.05
      2
                                           whole model-lr:0.25
                kd
      1
                kd
                                            whole model-lr:0.5
      3
                kd
                                          whole model-lr:0.125
      9
                    whole model-lr:lr_type.hundred_sample_size
                       learning_rate iteration \
      6
          lr_type.iteration_plus_one
                                          1476
      5
                   lr_type.iteration
                                          2220
      0
                                0.01
                                           956
      7
                 lr_type.sample_size
                                          2048
      8
             lr_type.ten_sample_size
                                          3516
      4
                                0.05
                                        150000
      2
                                0.25
                                        150000
      1
                                 0.5
                                        150000
      3
                               0.125
                                        150000
                                             2
         lr_type.hundred_sample_size
                                                    weights
                                                              epsilon elapsed_time \
        [[3.175241989157885], [9.517996847051375], [-1...
                                                         0.000001
                                                                            0.105
       [[3.6602142620593963], [11.56162794637247], [-... 0.000001
                                                                            0.162
      0 [[2.5819277747484066], [6.780007402086465], [-... 0.000001
                                                                            0.049
     7 [[2.5011580589018196], [6.514304926750582], [-...
                                                          0.000001
                                                                            0.155
       [[1.8917011563673924], [3.7425174840678586], [...
                                                          0.000001
                                                                            0.266
       [[9.970728371948313], [26.491694165903258], [-... 0.000001
                                                                            6.472
```

```
2 [[47.64433276868854], [130.6790054571249], [-1... 0.000001
                                                                          6.500
      1 [[95.81933692733199], [262.7825656994754], [-3... 0.000001
                                                                          8.592
      3 \quad [[24.070810464619214], [65.46666343519061], [-... 0.000001]
                                                                          8.383
      9 [[0.0003065942121212121], [0.00038259484848484... 0.000001
                                                                          0.000
       is_max_reached
                             loss
                                   accuracy_kfold
                                                        variable
      6
                False
                        16.436353
                                         0.751515 learning rate
      5
                False
                        17.234261
                                         0.750505 learning rate
      0
                False
                                                    all features
                        15.855793
                                         0.749495
      7
                False
                                         0.749495 learning rate
                        15.849570
                                         0.741414 learning rate
      8
                False
                        16.462365
      4
                 True
                       46.838322
                                         0.688552 learning rate
      2
                 True 106.221172
                                         0.683502 learning rate
      1
                 True
                       118.189617
                                         0.683165 learning rate
      3
                 True
                        87.970034
                                         0.683165 learning rate
      9
                False
                        20.585959
                                         0.516835 learning rate
[17]: #explore different epsilons
      epsilon_list = [1e-2,1e-3,1e-4,1e-5,1e-6,1e-7,1e-8,1e-9]
      for i in range(len(epsilon_list)):
       title = 'whole model-epsilon:' + str(epsilon_list[i])
       model_data = run_model('kd',title,learning_rate = 0, learning_rate_type = 0
       Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                             epsilon = epsilon_list[i],x_train = kd_x_train , y_train_
      ⇔= kd_y_train , model_data = model_data, variable = 'epsilon')
      show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
```

i====> 9

- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6 i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3 i====> 4
- i====> 5 i====> 6
- i====> 7

```
i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
「17]:
                                                     description
         model_name
                                       whole model-epsilon:1e-08
      16
                 kd
      14
                                       whole model-epsilon:1e-06
                 kd
      6
                 kd
                       whole model-lr:lr_type.iteration_plus_one
                                       whole model-epsilon:1e-07
      15
                 kd
      17
                 kd
                                       whole model-epsilon:1e-09
      5
                                whole model-lr:lr_type.iteration
                 kd
      13
                                       whole model-epsilon:1e-05
                 kd
      0
                 kd
                                                     whole model
      7
                 kd
                              whole model-lr:lr_type.sample_size
      12
                                      whole model-epsilon:0.0001
                 kd
                                       whole model-epsilon:0.001
      11
                 kd
      8
                 kd
                         whole model-lr:lr_type.ten_sample_size
      10
                 kd
                                        whole model-epsilon:0.01
                 kd
                                             whole model-lr:0.05
      2
                                             whole model-lr:0.25
                 kd
      1
                 kd
                                              whole model-lr:0.5
      3
                                            whole model-lr:0.125
                 kd
      9
                     whole model-lr:lr_type.hundred_sample_size
                 kd
                        learning_rate iteration \
      16
           lr_type.iteration_plus_one
                                            9021
           lr_type.iteration_plus_one
      14
                                            1476
           lr_type.iteration_plus_one
                                            1476
      6
      15
           lr_type.iteration_plus_one
                                            3643
      17
           lr_type.iteration_plus_one
                                           22164
      5
                    lr_type.iteration
                                            2220
      13
           lr_type.iteration_plus_one
                                             636
      0
                                  0.01
                                             956
      7
                  lr_type.sample_size
                                            2048
      12
           lr_type.iteration_plus_one
                                             314
      11
           lr_type.iteration_plus_one
                                             165
      8
              lr_type.ten_sample_size
                                            3516
      10
           lr_type.iteration_plus_one
                                              84
```

i====> 8

```
4
                            0.05
                                     150000
2
                            0.25
                                     150000
1
                             0.5
                                     150000
3
                           0.125
                                     150000
9
    lr_type.hundred_sample_size
                                          2
                                                 weights
                                                                epsilon \
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.00000e-08
    [[3.175241989157885], [9.517996847051375], [-1...
14
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
13
    [[3.3327577160627104], [10.39377495841507], [-...
                                                        1.000000e-05
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
    [[2.5011580589018196], [6.514304926750582], [-...
7
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
12
                                                        1.000000e-04
    [[4.254111597053624], [12.705390512862264], [-...
11
                                                        1.000000e-03
8
    [[1.8917011563673924], [3.7425174840678586], [...
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
    [[9.970728371948313], [26.491694165903258], [-...
4
                                                        1.000000e-06
2
    [[47.64433276868854], [130.6790054571249], [-1...
                                                        1.000000e-06
1
    [[95.81933692733199], [262.7825656994754], [-3...
                                                        1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
9
    [[0.0003065942121212121], [0.00038259484848484...
                                                        1.000000e-06
                                               accuracy_kfold
    elapsed_time is_max_reached
                                         loss
                                                                      variable
16
           0.413
                           False
                                    16.097559
                                                      0.751515
                                                                       epsilon
14
           0.072
                           False
                                    16.436353
                                                      0.751515
                                                                       epsilon
6
           0.105
                                                                 learning rate
                           False
                                    16.436353
                                                      0.751515
15
           0.166
                           False
                                    16.225842
                                                      0.751178
                                                                       epsilon
17
                           False
                                    16.019264
           0.940
                                                      0.750842
                                                                       epsilon
5
           0.162
                           False
                                    17.234261
                                                      0.750505
                                                                 learning rate
13
           0.027
                           False
                                    16.775910
                                                      0.749495
                                                                       epsilon
                           False
0
           0.049
                                    15.855793
                                                      0.749495
                                                                  all features
7
           0.155
                           False
                                    15.849570
                                                                 learning rate
                                                      0.749495
12
           0.013
                           False
                                    17.369442
                                                      0.747475
                                                                       epsilon
11
                           False
           0.009
                                    18.607920
                                                      0.743771
                                                                       epsilon
8
           0.266
                           False
                                    16.462365
                                                                 learning rate
                                                      0.741414
10
                           False
           0.009
                                    21.366778
                                                      0.737037
                                                                       epsilon
4
           6.472
                            True
                                    46.838322
                                                      0.688552
                                                                 learning rate
2
           6.500
                            True
                                   106.221172
                                                      0.683502
                                                                 learning rate
1
           8.592
                            True
                                   118.189617
                                                      0.683165
                                                                 learning rate
3
           8.383
                            True
                                    87.970034
                                                      0.683165
                                                                 learning rate
9
           0.000
                           False
                                    20.585959
                                                                 learning rate
                                                      0.516835
show_sorted_model(model_data)
```

```
[18]:
         model_name
                                                       description \
      16
                                        whole model-epsilon:1e-08
                 kd
      14
                 kd
                                        whole model-epsilon:1e-06
      6
                 kd
                       whole model-lr:lr_type.iteration_plus_one
                                        whole model-epsilon:1e-07
      15
                 kd
      17
                 kd
                                        whole model-epsilon:1e-09
      5
                 kd
                                whole model-lr:lr type.iteration
      13
                 kd
                                        whole model-epsilon:1e-05
      0
                                                       whole model
                 kd
      7
                              whole model-lr:lr_type.sample_size
                 kd
      12
                                       whole model-epsilon:0.0001
                 kd
                                        whole model-epsilon:0.001
      11
                 kd
      8
                          whole model-lr:lr_type.ten_sample_size
                 kd
      10
                                         whole model-epsilon:0.01
                 kd
      4
                 kd
                                              whole model-lr:0.05
      2
                 kd
                                              whole model-lr:0.25
      1
                 kd
                                               whole model-lr:0.5
      3
                 kd
                                             whole model-lr:0.125
      9
                      whole model-lr:lr_type.hundred_sample_size
                 kd
                         learning rate iteration \
      16
           lr type.iteration plus one
                                             9021
      14
           lr_type.iteration_plus_one
                                             1476
           lr_type.iteration_plus_one
      6
                                             1476
      15
           lr_type.iteration_plus_one
                                             3643
      17
           lr_type.iteration_plus_one
                                            22164
      5
                     lr_type.iteration
                                             2220
      13
           lr_type.iteration_plus_one
                                              636
      0
                                   0.01
                                              956
      7
                   lr_type.sample_size
                                             2048
           lr_type.iteration_plus_one
      12
                                              314
      11
           lr_type.iteration_plus_one
                                              165
      8
              lr type.ten sample size
                                             3516
      10
           lr_type.iteration_plus_one
                                               84
      4
                                  0.05
                                           150000
      2
                                  0.25
                                           150000
      1
                                           150000
                                    0.5
      3
                                           150000
                                 0.125
      9
                                                2
          lr_type.hundred_sample_size
                                                      weights
                                                                     epsilon \
          [[2.96533714092659], [8.33217514426845], [-1.0...
                                                              1.000000e-08
      16
      14
          [[3.175241989157885], [9.517996847051375], [-1...
                                                              1.000000e-06
          [[3.175241989157885], [9.517996847051375], [-1...
                                                              1.000000e-06
      6
          [[3.0601381991207917], [8.83862515342757], [-1...
      15
                                                              1.000000e-07
      17
          [[2.887385852612343], [7.9553323804450375], [-...
                                                              1.000000e-09
      5
          [[3.6602142620593963], [11.56162794637247], [-...
                                                              1.000000e-06
```

```
[[3.3327577160627104], [10.39377495841507], [-...
                                                               1.00000e-05
      13
      0
          [[2.5819277747484066], [6.780007402086465], [-...
                                                               1.000000e-06
      7
          [[2.5011580589018196], [6.514304926750582], [-...
                                                               1.000000e-06
          [[3.6109084400585387], [11.42702526345321], [-...
      12
                                                               1.000000e-04
          [[4.254111597053624], [12.705390512862264], [-...
      11
                                                               1.000000e-03
          [[1.8917011563673924], [3.7425174840678586], [...
      8
                                                               1.000000e-06
          [[5.958742925531525], [14.327917968306403], [-...
      10
                                                               1.000000e-02
      4
          [[9.970728371948313], [26.491694165903258], [-...
                                                               1.000000e-06
          [[47.64433276868854], [130.6790054571249], [-1...
      2
                                                               1.000000e-06
      1
          [[95.81933692733199], [262.7825656994754], [-3...
                                                               1.000000e-06
          [[24.070810464619214], [65.46666343519061], [-...
      3
                                                               1.000000e-06
      9
          [[0.0003065942121212121], [0.00038259484848484...
                                                               1.000000e-06
          elapsed_time is_max_reached
                                                loss
                                                      accuracy_kfold
                                                                             variable
      16
                  0.413
                                  False
                                           16.097559
                                                             0.751515
                                                                              epsilon
      14
                  0.072
                                  False
                                           16.436353
                                                             0.751515
                                                                              epsilon
      6
                  0.105
                                  False
                                           16.436353
                                                             0.751515
                                                                        learning rate
      15
                  0.166
                                  False
                                           16.225842
                                                             0.751178
                                                                              epsilon
      17
                  0.940
                                  False
                                           16.019264
                                                             0.750842
                                                                              epsilon
      5
                                  False
                  0.162
                                           17.234261
                                                             0.750505
                                                                        learning rate
      13
                  0.027
                                  False
                                           16.775910
                                                             0.749495
                                                                              epsilon
      0
                  0.049
                                  False
                                           15.855793
                                                             0.749495
                                                                         all features
      7
                                                                       learning rate
                  0.155
                                  False
                                           15.849570
                                                             0.749495
      12
                  0.013
                                  False
                                           17.369442
                                                             0.747475
                                                                              epsilon
      11
                                  False
                                          18.607920
                  0.009
                                                             0.743771
                                                                              epsilon
      8
                  0.266
                                  False
                                           16.462365
                                                             0.741414
                                                                       learning rate
      10
                  0.009
                                  False
                                          21.366778
                                                             0.737037
                                                                              epsilon
      4
                  6.472
                                   True
                                          46.838322
                                                             0.688552
                                                                        learning rate
      2
                  6.500
                                   True
                                         106.221172
                                                             0.683502
                                                                        learning rate
      1
                  8.592
                                         118.189617
                                                                        learning rate
                                   True
                                                             0.683165
      3
                  8.383
                                   True
                                          87.970034
                                                             0.683165
                                                                        learning rate
      9
                  0.000
                                  False
                                           20.585959
                                                                        learning rate
                                                             0.516835
[19]:
      show_sorted_model(model_data)
[19]:
         model_name
                                                       description \
      16
                  kd
                                        whole model-epsilon:1e-08
      14
                  kd
                                        whole model-epsilon:1e-06
      6
                  kd
                       whole model-lr:lr_type.iteration_plus_one
      15
                  kd
                                        whole model-epsilon:1e-07
      17
                                        whole model-epsilon:1e-09
                  kd
      5
                  kd
                                 whole model-lr:lr_type.iteration
      13
                                        whole model-epsilon:1e-05
                  kd
      0
                  kd
                                                       whole model
      7
                  kd
                               whole model-lr:lr_type.sample_size
      12
                                       whole model-epsilon:0.0001
                  kd
```

11

kd

whole model-epsilon:0.001

```
8
           kd
                    whole model-lr:lr_type.ten_sample_size
10
                                  whole model-epsilon:0.01
           kd
4
           kd
                                        whole model-lr:0.05
2
                                        whole model-lr:0.25
           kd
           kd
                                         whole model-lr:0.5
1
3
           kd
                                       whole model-lr:0.125
9
           kd
               whole model-lr:lr_type.hundred_sample_size
                   learning rate iteration \
16
     lr_type.iteration_plus_one
                                       9021
     lr type.iteration plus one
14
                                       1476
6
     lr_type.iteration_plus_one
                                       1476
15
     lr type.iteration plus one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
5
              lr_type.iteration
                                       2220
13
     lr_type.iteration_plus_one
                                        636
0
                            0.01
                                        956
7
            lr_type.sample_size
                                       2048
12
     lr_type.iteration_plus_one
                                        314
     lr_type.iteration_plus_one
11
                                        165
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
4
                            0.05
                                     150000
2
                            0.25
                                     150000
1
                             0.5
                                     150000
3
                           0.125
                                     150000
9
    lr_type.hundred_sample_size
                                          2
                                                weights
                                                               epsilon \
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.000000e-08
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
    [[2.887385852612343], [7.9553323804450375], [-...
17
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
13
    [[3.3327577160627104], [10.39377495841507], [-...
                                                        1.000000e-05
0
    [[2.5819277747484066], [6.780007402086465], [-...
                                                        1.000000e-06
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
12
                                                        1.000000e-04
    [[4.254111597053624], [12.705390512862264], [-...
11
                                                        1.000000e-03
    [[1.8917011563673924], [3.7425174840678586], [...
8
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
    [[9.970728371948313], [26.491694165903258], [-...
4
                                                        1.000000e-06
    [[47.64433276868854], [130.6790054571249], [-1...
                                                        1.000000e-06
2
    [[95.81933692733199], [262.7825656994754], [-3...
1
                                                        1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
    [[0.0003065942121212121], [0.00038259484848484...
9
                                                        1.000000e-06
```

```
elapsed_time is_max_reached
                                                accuracy_kfold
                                         loss
                                                                      variable
16
           0.413
                           False
                                    16.097559
                                                      0.751515
                                                                       epsilon
           0.072
                           False
14
                                    16.436353
                                                      0.751515
                                                                       epsilon
6
           0.105
                           False
                                    16.436353
                                                                 learning rate
                                                      0.751515
15
           0.166
                           False
                                    16.225842
                                                      0.751178
                                                                       epsilon
17
           0.940
                           False
                                    16.019264
                                                      0.750842
                                                                       epsilon
5
                           False
                                    17.234261
           0.162
                                                      0.750505
                                                                 learning rate
13
           0.027
                                    16.775910
                           False
                                                      0.749495
                                                                       epsilon
0
           0.049
                           False
                                    15.855793
                                                      0.749495
                                                                  all features
7
           0.155
                           False
                                                                 learning rate
                                    15.849570
                                                      0.749495
12
           0.013
                           False
                                    17.369442
                                                      0.747475
                                                                       epsilon
11
           0.009
                           False
                                    18.607920
                                                      0.743771
                                                                       epsilon
8
           0.266
                           False
                                    16.462365
                                                      0.741414
                                                                 learning rate
10
           0.009
                           False
                                    21.366778
                                                      0.737037
                                                                       epsilon
4
           6.472
                            True
                                    46.838322
                                                      0.688552
                                                                 learning rate
2
           6.500
                            True
                                   106.221172
                                                      0.683502
                                                                 learning rate
1
           8.592
                                   118.189617
                            True
                                                      0.683165
                                                                 learning rate
3
           8.383
                            True
                                    87.970034
                                                      0.683165
                                                                 learning rate
9
           0.000
                           False
                                    20.585959
                                                      0.516835
                                                                 learning rate
```

```
[20]: kd_x_train_np = pd.DataFrame(kd_x_train)
```

```
0 ,log , column=> Pregnancies
i=====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,log , column=> Glucose
i====> 0
```

```
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,log , column=> BloodPressure
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
3 ,log , column=> Heart Rate
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,log , column=> SkinThickness
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,log , column=> Insulin
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
```

```
i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     6 ,log , column=> BMI
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     7 ,log , column=> DiabetesPedigreeFunction
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     8 ,log , column=> Age
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[21]:
        model_name
                                                 description \
     23
                                                 log Insulin
               kd
     25
               kd
                                log DiabetesPedigreeFunction
     26
               kd
                                                    log Age
                                   whole model-epsilon:1e-06
     14
               kd
     6
               kd
                    whole model-lr:lr_type.iteration_plus_one
     16
                                   whole model-epsilon:1e-08
               kd
     15
               kd
                                   whole model-epsilon:1e-07
```

```
17
           kd
                                 whole model-epsilon:1e-09
5
                          whole model-lr:lr_type.iteration
           kd
18
           kd
                                            log Pregnancies
                                                whole model
0
           kd
7
           kd
                        whole model-lr:lr_type.sample_size
13
                                 whole model-epsilon:1e-05
           kd
19
           kd
                                                log Glucose
12
                                whole model-epsilon:0.0001
           kd
24
                                                    log BMI
           kd
22
           kd
                                          log SkinThickness
21
                                             log Heart Rate
           kd
11
           kd
                                 whole model-epsilon:0.001
20
           kd
                                          log BloodPressure
8
                    whole model-lr:lr_type.ten_sample_size
           kd
10
                                   whole model-epsilon:0.01
           kd
4
                                        whole model-lr:0.05
           kd
2
           kd
                                        whole model-lr:0.25
1
           kd
                                         whole model-lr:0.5
3
                                       whole model-lr:0.125
           kd
9
           kd
               whole model-lr:lr_type.hundred_sample_size
                   learning rate iteration
23
     lr_type.iteration_plus_one
                                        802
25
     lr type.iteration plus one
                                       1118
     lr_type.iteration_plus_one
26
                                       1425
14
     lr_type.iteration_plus_one
                                       1476
     lr_type.iteration_plus_one
6
                                       1476
16
     lr_type.iteration_plus_one
                                       9021
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
5
              lr_type.iteration
                                       2220
18
     lr_type.iteration_plus_one
                                       1129
0
                            0.01
                                        956
7
            lr_type.sample_size
                                       2048
13
     lr_type.iteration_plus_one
                                        636
19
     lr_type.iteration_plus_one
                                        560
12
     lr_type.iteration_plus_one
                                        314
24
     lr_type.iteration_plus_one
                                       1341
22
     lr type.iteration plus one
                                       1075
21
     lr_type.iteration_plus_one
                                       1008
11
     lr_type.iteration_plus_one
                                        165
20
     lr_type.iteration_plus_one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
                                     150000
4
                            0.05
2
                            0.25
                                     150000
1
                                     150000
                             0.5
```

```
9
    lr type.hundred sample size
                                          2
                                                 weights
                                                                epsilon \
23
    [[2.686500388124719], [8.005602930239544], [-0...
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
26
    [[3.2317379647520714], [9.47235968785085], [-1...
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
14
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.000000e-08
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
18
    [[0.47048312539781034], [8.606990965621858], [...
                                                        1.000000e-06
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
    [[2.5011580589018196], [6.514304926750582], [-...
7
                                                        1.000000e-06
    [[3.3327577160627104], [10.39377495841507], [-...
13
                                                        1.000000e-05
    [[2.7341191226158608], [1.1070301791999142], [...
19
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
12
                                                        1.000000e-04
24
    [[3.016669053499772], [9.333632805388874], [-1...
                                                        1.000000e-06
    [[3.097120568287582], [8.175406022439612], [-1...
22
                                                        1.000000e-06
21
    [[2.7030305464057154], [8.683157932519787], [-...
                                                        1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
                                                        1.000000e-03
11
20
    [[3.0167390363517588], [8.607754261039704], [0...
                                                        1.000000e-06
8
    [[1.8917011563673924], [3.7425174840678586], [...
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
    [[9.970728371948313], [26.491694165903258], [-...
4
                                                        1.000000e-06
2
    [[47.64433276868854], [130.6790054571249], [-1...
                                                        1.000000e-06
1
    [[95.81933692733199], [262.7825656994754], [-3...
                                                        1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
9
    [[0.0003065942121212121], [0.00038259484848484...
                                                        1.000000e-06
    elapsed_time is_max_reached
                                         loss
                                               accuracy_kfold
                                                                      variable
23
           0.037
                           False
                                    15.821280
                                                      0.755556
                                                                           log
25
           0.051
                           False
                                    16.145685
                                                      0.751852
                                                                           log
26
           0.070
                           False
                                    16.404716
                                                      0.751515
                                                                           log
           0.072
14
                           False
                                    16.436353
                                                      0.751515
                                                                       epsilon
6
                           False
                                    16.436353
                                                                learning rate
           0.105
                                                      0.751515
16
           0.413
                           False
                                    16.097559
                                                                       epsilon
                                                      0.751515
                           False
15
           0.166
                                    16.225842
                                                      0.751178
                                                                       epsilon
17
           0.940
                           False
                                    16.019264
                                                      0.750842
                                                                       epsilon
5
           0.162
                           False
                                    17.234261
                                                      0.750505
                                                                 learning rate
18
           0.048
                           False
                                    16.526437
                                                      0.750168
                                                                           log
0
           0.049
                                    15.855793
                           False
                                                      0.749495
                                                                  all features
7
           0.155
                           False
                                    15.849570
                                                                 learning rate
                                                      0.749495
                           False
                                    16.775910
13
           0.027
                                                      0.749495
                                                                       epsilon
19
           0.023
                           False
                                    16.070200
                                                      0.748485
                                                                           log
```

150000

0.125

3

```
0.013
12
                           False
                                    17.369442
                                                       0.747475
                                                                        epsilon
24
           0.056
                                    16.234284
                            False
                                                       0.747138
                                                                            log
22
           0.069
                            False
                                    16.334522
                                                       0.746465
                                                                            log
                            False
21
           0.044
                                    16.245876
                                                       0.744781
                                                                            log
           0.009
                           False
                                    18.607920
                                                       0.743771
                                                                        epsilon
11
20
                            False
           0.052
                                    16.291746
                                                       0.743434
                                                                            log
8
           0.266
                            False
                                    16.462365
                                                       0.741414
                                                                 learning rate
10
           0.009
                            False
                                    21.366778
                                                       0.737037
                                                                        epsilon
4
           6.472
                                    46.838322
                                                                 learning rate
                             True
                                                       0.688552
2
           6.500
                             True
                                  106.221172
                                                                 learning rate
                                                       0.683502
1
                                   118.189617
                                                                 learning rate
           8.592
                             True
                                                       0.683165
3
           8.383
                             True
                                    87.970034
                                                       0.683165
                                                                 learning rate
9
           0.000
                            False
                                    20.585959
                                                       0.516835
                                                                 learning rate
```

```
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
```

```
[22]:
         model_name
                                                      description \
                                                  log age-insulin
                 kd
      23
                 kd
                                                      log Insulin
      25
                 kd
                                    log DiabetesPedigreeFunction
                       whole model-lr:lr_type.iteration_plus_one
      6
                 kd
      26
                 kd
                                                          log Age
      16
                 kd
                                       whole model-epsilon:1e-08
                                       whole model-epsilon:1e-06
      14
                 kd
      15
                 kd
                                       whole model-epsilon:1e-07
      17
                 kd
                                        whole model-epsilon:1e-09
      5
                 kd
                                whole model-lr:lr_type.iteration
```

```
18
           kd
                                            log Pregnancies
13
           kd
                                 whole model-epsilon:1e-05
7
           kd
                        whole model-lr:lr_type.sample_size
0
                                                whole model
           kd
19
           kd
                                                log Glucose
12
                                whole model-epsilon:0.0001
           kd
24
           kd
                                                     log BMI
22
           kd
                                          log SkinThickness
21
                                             log Heart Rate
           kd
11
           kd
                                 whole model-epsilon:0.001
20
                                          log BloodPressure
           kd
8
           kd
                    whole model-lr:lr_type.ten_sample_size
10
           kd
                                   whole model-epsilon:0.01
4
                                        whole model-lr:0.05
           kd
2
           kd
                                        whole model-lr:0.25
                                         whole model-lr:0.5
1
           kd
3
           kd
                                       whole model-lr:0.125
9
           kd
               whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration
27
     lr_type.iteration_plus_one
                                        836
23
     lr type.iteration plus one
                                        802
25
     lr_type.iteration_plus_one
                                       1118
6
     lr type.iteration plus one
                                       1476
26
     lr type.iteration plus one
                                       1425
16
     lr type.iteration plus one
                                       9021
                                       1476
14
     lr_type.iteration_plus_one
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
5
              lr_type.iteration
                                       2220
18
     lr_type.iteration_plus_one
                                       1129
13
     lr_type.iteration_plus_one
                                        636
7
            lr_type.sample_size
                                       2048
0
                            0.01
                                        956
19
     lr_type.iteration_plus_one
                                        560
12
     lr_type.iteration_plus_one
                                        314
24
     lr_type.iteration_plus_one
                                       1341
22
     lr_type.iteration_plus_one
                                       1075
21
     lr type.iteration plus one
                                       1008
11
     lr_type.iteration_plus_one
                                        165
20
     lr type.iteration plus one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
                            0.05
4
                                     150000
2
                            0.25
                                     150000
                                     150000
1
                             0.5
3
                           0.125
                                     150000
```

```
weights
                                                                epsilon \
    [[2.7683606646024232], [8.122909449757739], [-...
27
                                                        1.000000e-06
23
    [[2.686500388124719], [8.005602930239544], [-0...
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
    [[3.2317379647520714], [9.47235968785085], [-1...
26
                                                        1.000000e-06
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.000000e-08
    [[3.175241989157885], [9.517996847051375], [-1...
14
                                                        1.000000e-06
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
18
    [[0.47048312539781034], [8.606990965621858], [...
                                                        1.000000e-06
    [[3.3327577160627104], [10.39377495841507], [-...
13
                                                        1.000000e-05
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
19
    [[2.7341191226158608], [1.1070301791999142], [...
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
12
                                                        1.000000e-04
24
    [[3.016669053499772], [9.333632805388874], [-1...
                                                        1.000000e-06
    [[3.097120568287582], [8.175406022439612], [-1...
22
                                                        1.000000e-06
21
    [[2.7030305464057154], [8.683157932519787], [-...
                                                        1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
                                                        1.000000e-03
11
20
    [[3.0167390363517588], [8.607754261039704], [0...
                                                        1.000000e-06
8
    [[1.8917011563673924], [3.7425174840678586], [...
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
    [[9.970728371948313], [26.491694165903258], [-...
4
                                                        1.000000e-06
2
    [[47.64433276868854], [130.6790054571249], [-1...
                                                        1.000000e-06
1
    [[95.81933692733199], [262.7825656994754], [-3...
                                                        1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
9
    [[0.0003065942121212121], [0.00038259484848484...
                                                        1.000000e-06
    elapsed_time is_max_reached
                                         loss
                                               accuracy_kfold
                                                                      variable
27
           0.035
                           False
                                    15.737679
                                                      0.757576
                                                                           log
23
           0.037
                           False
                                    15.821280
                                                      0.755556
                                                                           log
25
           0.051
                           False
                                    16.145685
                                                      0.751852
                                                                           log
6
           0.105
                           False
                                    16.436353
                                                      0.751515
                                                                learning rate
26
                           False
                                                                           log
           0.070
                                    16.404716
                                                      0.751515
16
           0.413
                           False
                                    16.097559
                                                                       epsilon
                                                      0.751515
                           False
14
           0.072
                                    16.436353
                                                      0.751515
                                                                       epsilon
15
           0.166
                           False
                                    16.225842
                                                      0.751178
                                                                       epsilon
17
           0.940
                           False
                                    16.019264
                                                      0.750842
                                                                       epsilon
5
           0.162
                           False
                                    17.234261
                                                      0.750505
                                                                learning rate
18
           0.048
                                    16.526437
                           False
                                                      0.750168
                                                                           log
13
           0.027
                           False
                                    16.775910
                                                      0.749495
                                                                       epsilon
7
           0.155
                           False
                                    15.849570
                                                      0.749495
                                                                learning rate
                                                      0.749495
0
           0.049
                           False
                                    15.855793
                                                                  all features
```

```
19
           0.023
                                    16.070200
                           False
                                                       0.748485
                                                                            log
12
           0.013
                                    17.369442
                           False
                                                       0.747475
                                                                        epsilon
24
           0.056
                           False
                                    16.234284
                                                       0.747138
                                                                            log
22
                            False
           0.069
                                    16.334522
                                                       0.746465
                                                                            log
21
           0.044
                           False
                                    16.245876
                                                       0.744781
                                                                            log
                                    18.607920
           0.009
                           False
11
                                                       0.743771
                                                                        epsilon
20
           0.052
                           False
                                    16.291746
                                                       0.743434
                                                                            log
8
           0.266
                           False
                                    16.462365
                                                                 learning rate
                                                       0.741414
10
           0.009
                                    21.366778
                           False
                                                       0.737037
                                                                        epsilon
4
           6.472
                             True
                                    46.838322
                                                       0.688552
                                                                 learning rate
2
           6.500
                                   106.221172
                                                                 learning rate
                             True
                                                       0.683502
1
           8.592
                             True
                                  118.189617
                                                       0.683165
                                                                 learning rate
3
           8.383
                             True
                                    87.970034
                                                       0.683165
                                                                 learning rate
9
           0.000
                                    20.585959
                            False
                                                       0.516835
                                                                 learning rate
```

```
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
```

```
[23]:
         model_name
                                                       description \
      27
                                                  log age-insulin
                 kd
      28
                                              log age-insulin-Dpf
                 kd
      23
                 kd
                                                       log Insulin
                                    log DiabetesPedigreeFunction
      25
                 kd
                 kd
                                        whole model-epsilon:1e-08
      16
      26
                 kd
                                                           log Age
      14
                 kd
                                        whole model-epsilon:1e-06
      6
                 kd
                       whole model-lr:lr_type.iteration_plus_one
      15
                 kd
                                        whole model-epsilon:1e-07
      17
                 kd
                                        whole model-epsilon:1e-09
```

```
5
           kd
                          whole model-lr:lr_type.iteration
18
                                            log Pregnancies
           kd
                                 whole model-epsilon:1e-05
13
           kd
7
                        whole model-lr:lr_type.sample_size
           kd
0
           kd
                                                whole model
19
                                                log Glucose
           kd
                                whole model-epsilon:0.0001
12
           kd
24
           kd
                                                    log BMI
22
                                          log SkinThickness
           kd
21
           kd
                                             log Heart Rate
11
           kd
                                 whole model-epsilon:0.001
                                          log BloodPressure
20
           kd
           kd
                    whole model-lr:lr_type.ten_sample_size
10
                                   whole model-epsilon:0.01
           kd
4
                                        whole model-lr:0.05
           kd
2
                                        whole model-lr:0.25
           kd
1
           kd
                                         whole model-lr:0.5
3
           kd
                                       whole model-lr:0.125
9
               whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration
27
     lr_type.iteration_plus_one
                                        836
28
     lr_type.iteration_plus_one
                                        742
23
     lr type.iteration plus one
                                        802
25
     lr_type.iteration_plus_one
                                       1118
16
     lr_type.iteration_plus_one
                                       9021
     lr_type.iteration_plus_one
26
                                       1425
14
     lr_type.iteration_plus_one
                                       1476
     lr_type.iteration_plus_one
6
                                       1476
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
5
              lr_type.iteration
                                       2220
18
     lr_type.iteration_plus_one
                                       1129
13
     lr_type.iteration_plus_one
                                        636
7
            lr_type.sample_size
                                       2048
0
                            0.01
                                        956
19
     lr_type.iteration_plus_one
                                        560
12
     lr_type.iteration_plus_one
                                        314
24
     lr type.iteration plus one
                                       1341
22
     lr_type.iteration_plus_one
                                       1075
21
     lr_type.iteration_plus_one
                                       1008
     lr_type.iteration_plus_one
11
                                        165
20
     lr_type.iteration_plus_one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
4
                                     150000
                            0.05
2
                            0.25
                                     150000
```

```
3
                           0.125
                                     150000
9
    lr_type.hundred_sample_size
                                          2
                                                weights
                                                               epsilon \
    [[2.7683606646024232], [8.122909449757739], [-...
27
                                                        1.000000e-06
28
    [[2.81722351586145], [8.11597903143088], [-0.8...
                                                        1.000000e-06
    [[2.686500388124719], [8.005602930239544], [-0...
23
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.000000e-08
    [[3.2317379647520714], [9.47235968785085], [-1...
26
                                                        1.000000e-06
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
6
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
15
    [[3.0601381991207917], [8.83862515342757], [-1...
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
    [[3.6602142620593963], [11.56162794637247], [-...
5
                                                        1.000000e-06
18
    [[0.47048312539781034], [8.606990965621858], [...
                                                        1.000000e-06
    [[3.3327577160627104], [10.39377495841507], [-...
13
                                                        1.000000e-05
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
    [[2.7341191226158608], [1.1070301791999142], [...
19
                                                        1.000000e-06
12
    [[3.6109084400585387], [11.42702526345321], [-...
                                                        1.000000e-04
24
    [[3.016669053499772], [9.333632805388874], [-1...
                                                        1.000000e-06
22
    [[3.097120568287582], [8.175406022439612], [-1...
                                                        1.000000e-06
21
    [[2.7030305464057154], [8.683157932519787], [-...
                                                        1.000000e-06
11
    [[4.254111597053624], [12.705390512862264], [-...
                                                        1.000000e-03
20
    [[3.0167390363517588], [8.607754261039704], [0...
                                                        1.000000e-06
    [[1.8917011563673924], [3.7425174840678586], [...
8
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
4
    [[9.970728371948313], [26.491694165903258], [-...
                                                        1.000000e-06
2
    [[47.64433276868854], [130.6790054571249], [-1...
                                                        1.000000e-06
    [[95.81933692733199], [262.7825656994754], [-3...
1
                                                        1.000000e-06
3
    [[24.070810464619214], [65.46666343519061], [-...
                                                        1.000000e-06
    [[0.0003065942121212121], [0.00038259484848484...
9
                                                        1.000000e-06
    elapsed_time is_max_reached
                                                                      variable
                                               accuracy_kfold
                                         loss
27
           0.035
                           False
                                    15.737679
                                                      0.757576
                                                                           log
28
           0.036
                           False
                                    15.629731
                                                      0.756902
                                                                           log
23
           0.037
                           False
                                    15.821280
                                                      0.755556
                                                                           log
                           False
25
           0.051
                                    16.145685
                                                      0.751852
                                                                           log
16
           0.413
                           False
                                    16.097559
                                                      0.751515
                                                                       epsilon
26
           0.070
                           False
                                    16.404716
                                                      0.751515
                                                                           log
                                                                       epsilon
14
           0.072
                           False
                                    16.436353
                                                      0.751515
6
           0.105
                           False
                                    16.436353
                                                      0.751515
                                                                 learning rate
15
           0.166
                           False
                                    16.225842
                                                      0.751178
                                                                       epsilon
17
           0.940
                           False
                                    16.019264
                                                      0.750842
                                                                       epsilon
5
           0.162
                           False
                                    17.234261
                                                      0.750505
                                                                 learning rate
```

0.5

150000

1

```
18
                 0.048
                                 False
                                         16.526437
                                                           0.750168
                                                                                log
                 0.027
      13
                                 False
                                         16.775910
                                                           0.749495
                                                                            epsilon
      7
                 0.155
                                 False
                                         15.849570
                                                           0.749495
                                                                      learning rate
      0
                 0.049
                                 False
                                         15.855793
                                                           0.749495
                                                                       all features
      19
                 0.023
                                 False
                                         16.070200
                                                           0.748485
                                                                                log
      12
                 0.013
                                 False
                                         17.369442
                                                           0.747475
                                                                            epsilon
      24
                 0.056
                                 False
                                         16.234284
                                                           0.747138
                                                                                log
      22
                                 False
                                         16.334522
                 0.069
                                                           0.746465
                                                                                log
      21
                                         16.245876
                 0.044
                                 False
                                                           0.744781
                                                                                log
      11
                 0.009
                                 False
                                         18.607920
                                                           0.743771
                                                                            epsilon
      20
                                 False
                                         16.291746
                 0.052
                                                           0.743434
                                                                                log
      8
                 0.266
                                 False
                                         16.462365
                                                           0.741414
                                                                      learning rate
      10
                 0.009
                                 False
                                         21.366778
                                                           0.737037
                                                                            epsilon
      4
                 6.472
                                  True
                                         46.838322
                                                           0.688552
                                                                      learning rate
      2
                 6.500
                                  True
                                        106.221172
                                                           0.683502
                                                                      learning rate
      1
                 8.592
                                  True
                                        118.189617
                                                           0.683165
                                                                      learning rate
      3
                 8.383
                                  True
                                         87.970034
                                                                      learning rate
                                                           0.683165
      9
                 0.000
                                         20.585959
                                 False
                                                           0.516835
                                                                      learning rate
[24]: #combine log bmi-skintickness
      kd_x_train_log_skin = log_transform_normalize(kd_x_train_np,4)
      kd x train skinbmi = log transform normalize(kd x train log skin,6)
      model_data = run_model('kd','log_skin-bmi',learning_rate = 0,_
       →learning_rate_type = learning_rate_type.iteration_plus_one ,max_iterations =

→150000.

                              epsilon = 1e-6,x_train = kd_x_train_skinbmi , y_train =_
       ⇒kd_y_train , model_data = model_data, variable = 'log')
      show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[24]:
         model_name
                                                      description \
      27
                                                  log age-insulin
                 kd
      28
                 kd
                                             log age-insulin-Dpf
      23
                                                      log Insulin
                 kd
      25
                 kd
                                    log DiabetesPedigreeFunction
      26
                 kd
                                                          log Age
```

```
6
           kd
                 whole model-lr:lr_type.iteration_plus_one
16
           kd
                                 whole model-epsilon:1e-08
14
           kd
                                 whole model-epsilon:1e-06
15
                                 whole model-epsilon:1e-07
           kd
17
           kd
                                 whole model-epsilon:1e-09
5
                          whole model-lr:lr_type.iteration
           kd
18
           kd
                                            log Pregnancies
13
                                 whole model-epsilon:1e-05
           kd
0
                                                whole model
           kd
7
           kd
                        whole model-lr:lr_type.sample_size
19
           kd
                                                log Glucose
12
           kd
                                whole model-epsilon:0.0001
24
           kd
                                                    log BMI
22
                                          log SkinThickness
           kd
21
                                             log Heart Rate
           kd
29
           kd
                                               log skin-bmi
                                 whole model-epsilon:0.001
11
           kd
20
                                          log BloodPressure
           kd
8
           kd
                    whole model-lr:lr_type.ten_sample_size
10
                                  whole model-epsilon:0.01
           kd
4
                                        whole model-lr:0.05
           kd
           kd
2
                                        whole model-lr:0.25
1
           kd
                                         whole model-lr:0.5
3
                                       whole model-lr:0.125
           kd
9
           kd
               whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration
27
     lr_type.iteration_plus_one
                                        836
28
     lr_type.iteration_plus_one
                                        742
23
     lr_type.iteration_plus_one
                                       802
25
     lr_type.iteration_plus_one
                                       1118
26
     lr_type.iteration_plus_one
                                       1425
6
     lr_type.iteration_plus_one
                                       1476
16
     lr_type.iteration_plus_one
                                       9021
14
     lr_type.iteration_plus_one
                                       1476
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
5
              lr_type.iteration
                                       2220
18
     lr_type.iteration_plus_one
                                       1129
13
     lr_type.iteration_plus_one
                                        636
0
                                        956
7
            lr_type.sample_size
                                       2048
19
     lr_type.iteration_plus_one
                                        560
12
     lr_type.iteration_plus_one
                                       314
24
     lr_type.iteration_plus_one
                                       1341
22
     lr_type.iteration_plus_one
                                       1075
21
     lr_type.iteration_plus_one
                                       1008
```

```
lr_type.iteration_plus_one
11
                                        165
20
     lr_type.iteration_plus_one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
4
                            0.05
                                     150000
2
                            0.25
                                     150000
1
                                     150000
                             0.5
3
                                     150000
                           0.125
9
                                          2
    lr_type.hundred_sample_size
                                                weights
                                                               epsilon \
27
    [[2.7683606646024232], [8.122909449757739], [-...
                                                        1.000000e-06
    [[2.81722351586145], [8.11597903143088], [-0.8...
28
                                                        1.000000e-06
    [[2.686500388124719], [8.005602930239544], [-0...
23
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
    [[3.2317379647520714], [9.47235968785085], [-1...
26
                                                        1.000000e-06
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
16
    [[2.96533714092659], [8.33217514426845], [-1.0...
                                                        1.000000e-08
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
    [[0.47048312539781034], [8.606990965621858], [...
18
                                                        1.000000e-06
    [[3.3327577160627104], [10.39377495841507], [-...
13
                                                        1.000000e-05
0
    [[2.5819277747484066], [6.780007402086465], [-...
                                                        1.000000e-06
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
    [[2.7341191226158608], [1.1070301791999142], [...
19
                                                        1.000000e-06
12
    [[3.6109084400585387], [11.42702526345321], [-...
                                                        1.000000e-04
    [[3.016669053499772], [9.333632805388874], [-1...
24
                                                        1.000000e-06
22
    [[3.097120568287582], [8.175406022439612], [-1...
                                                        1.000000e-06
    [[2.7030305464057154], [8.683157932519787], [-...
21
                                                        1.000000e-06
    [[2.989559318463753], [8.044352212204572], [-1...
29
                                                        1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
11
                                                        1.000000e-03
20
    [[3.0167390363517588], [8.607754261039704], [0...
                                                        1.000000e-06
8
    [[1.8917011563673924], [3.7425174840678586], [...
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
4
    [[9.970728371948313], [26.491694165903258], [-...
                                                        1.000000e-06
    [[47.64433276868854], [130.6790054571249], [-1...
2
                                                        1.000000e-06
    [[95.81933692733199], [262.7825656994754], [-3...
                                                        1.000000e-06
1
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
9
    [[0.0003065942121212121], [0.00038259484848484...
                                                        1.000000e-06
    elapsed_time is_max_reached
                                         loss
                                               accuracy_kfold
                                                                     variable
                                    15.737679
27
           0.035
                           False
                                                     0.757576
                                                                           log
28
           0.036
                           False
                                    15.629731
                                                     0.756902
                                                                           log
23
           0.037
                           False
                                    15.821280
                                                     0.755556
                                                                           log
```

978

29

lr_type.iteration_plus_one

```
0.051
25
                            False
                                    16.145685
                                                       0.751852
                                                                             log
26
           0.070
                            False
                                     16.404716
                                                       0.751515
                                                                             log
6
           0.105
                            False
                                     16.436353
                                                       0.751515
                                                                  learning rate
16
           0.413
                            False
                                     16.097559
                                                       0.751515
                                                                         epsilon
14
           0.072
                            False
                                     16.436353
                                                                         epsilon
                                                       0.751515
15
           0.166
                            False
                                    16.225842
                                                       0.751178
                                                                         epsilon
17
           0.940
                            False
                                    16.019264
                                                       0.750842
                                                                         epsilon
5
                                                                  learning rate
           0.162
                            False
                                     17.234261
                                                       0.750505
18
           0.048
                            False
                                     16.526437
                                                       0.750168
                                                                             log
13
           0.027
                            False
                                                       0.749495
                                                                         epsilon
                                     16.775910
                            False
                                                                   all features
0
           0.049
                                     15.855793
                                                       0.749495
7
           0.155
                            False
                                    15.849570
                                                       0.749495
                                                                  learning rate
19
           0.023
                            False
                                    16.070200
                                                       0.748485
                                                                             log
12
           0.013
                            False
                                    17.369442
                                                       0.747475
                                                                         epsilon
24
           0.056
                            False
                                     16.234284
                                                       0.747138
                                                                             log
22
           0.069
                            False
                                     16.334522
                                                       0.746465
                                                                             log
21
           0.044
                            False
                                     16.245876
                                                       0.744781
                                                                             log
29
           0.061
                            False
                                     16.176293
                                                       0.744108
                                                                             log
11
           0.009
                            False
                                     18.607920
                                                       0.743771
                                                                         epsilon
                                    16.291746
20
           0.052
                            False
                                                       0.743434
                                                                             log
8
           0.266
                            False
                                    16.462365
                                                       0.741414
                                                                  learning rate
10
           0.009
                                    21.366778
                                                       0.737037
                            False
                                                                        epsilon
4
           6.472
                                    46.838322
                                                       0.688552
                                                                  learning rate
                             True
2
                                                                  learning rate
           6.500
                             True
                                   106.221172
                                                       0.683502
1
                                   118.189617
                                                                  learning rate
           8.592
                             True
                                                       0.683165
3
           8.383
                             True
                                    87.970034
                                                       0.683165
                                                                  learning rate
9
           0.000
                            False
                                    20.585959
                                                       0.516835
                                                                  learning rate
```

i====> 0
i====> 1
i====> 2
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9

```
[25]:
         model_name
                                                      description \
      30
                                                  log age-insulin
                 kd
      27
                 kd
                                                  log age-insulin
      28
                 kd
                                              log age-insulin-Dpf
      23
                                                      log Insulin
                 kd
      25
                 kd
                                    log DiabetesPedigreeFunction
      14
                 kd
                                       whole model-epsilon:1e-06
      26
                 kd
                                                           log Age
      6
                 kd
                       whole model-lr:lr_type.iteration_plus_one
      16
                                       whole model-epsilon:1e-08
                 kd
      15
                                       whole model-epsilon:1e-07
                 kd
      17
                 kd
                                       whole model-epsilon:1e-09
      5
                 kd
                                whole model-lr:lr_type.iteration
      18
                 kd
                                                  log Pregnancies
                                                      whole model
                 kd
      7
                 kd
                              whole model-lr:lr_type.sample_size
      13
                 kd
                                       whole model-epsilon:1e-05
                                                      log Glucose
      19
                 kd
      12
                 kd
                                      whole model-epsilon:0.0001
      24
                 kd
                                                           log BMI
      22
                 kd
                                                log SkinThickness
      21
                                                   log Heart Rate
                 kd
      29
                 kd
                                                     log skin-bmi
                                       whole model-epsilon:0.001
      11
                 kd
      20
                 kd
                                                log BloodPressure
      8
                          whole model-lr:lr_type.ten_sample_size
                 kd
      10
                                         whole model-epsilon:0.01
                 kd
      4
                                              whole model-lr:0.05
                 kd
      2
                                              whole model-lr:0.25
                 kd
      1
                 kd
                                               whole model-lr:0.5
      3
                                             whole model-lr:0.125
                 kd
      9
                 kd
                     whole model-lr:lr_type.hundred_sample_size
                         learning_rate iteration
      30
           lr type.iteration plus one
                                              836
      27
           lr type.iteration plus one
                                              836
      28
           lr type.iteration plus one
                                              742
      23
           lr_type.iteration_plus_one
                                              802
      25
           lr_type.iteration_plus_one
                                             1118
      14
           lr_type.iteration_plus_one
                                             1476
      26
           lr_type.iteration_plus_one
                                             1425
      6
           lr_type.iteration_plus_one
                                             1476
      16
           lr_type.iteration_plus_one
                                             9021
      15
           lr_type.iteration_plus_one
                                             3643
      17
           lr_type.iteration_plus_one
                                            22164
      5
                     lr_type.iteration
                                             2220
      18
           lr_type.iteration_plus_one
                                             1129
```

```
0
                            0.01
                                        956
7
            lr_type.sample_size
                                       2048
13
     lr_type.iteration_plus_one
                                        636
19
     lr_type.iteration_plus_one
                                        560
12
     lr_type.iteration_plus_one
                                        314
24
     lr_type.iteration_plus_one
                                       1341
22
     lr_type.iteration_plus_one
                                       1075
21
     lr_type.iteration_plus_one
                                       1008
29
     lr type.iteration plus one
                                        978
     lr_type.iteration_plus_one
11
                                        165
20
     lr type.iteration plus one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
10
     lr_type.iteration_plus_one
                                         84
4
                            0.05
                                     150000
2
                            0.25
                                     150000
1
                             0.5
                                     150000
3
                           0.125
                                     150000
9
    lr_type.hundred_sample_size
                                          2
                                                               epsilon \
                                                weights
    [[2.7683606646024232], [8.122909449757739], [-...
30
                                                        1.000000e-06
27
    [[2.7683606646024232], [8.122909449757739], [-...
                                                        1.000000e-06
28
    [[2.81722351586145], [8.11597903143088], [-0.8...
                                                        1.000000e-06
23
    [[2.686500388124719], [8.005602930239544], [-0...
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                       1.000000e-06
    [[3.2317379647520714], [9.47235968785085], [-1...
                                                        1.000000e-06
26
    [[3.175241989157885], [9.517996847051375], [-1...
6
                                                        1.000000e-06
16
    [[2.96533714092659], [8.33217514426845], [-1.0...
                                                        1.000000e-08
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
    [[2.887385852612343], [7.9553323804450375], [-...
17
                                                        1.000000e-09
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
    [[0.47048312539781034], [8.606990965621858], [...
18
                                                        1.000000e-06
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
13
    [[3.3327577160627104], [10.39377495841507], [-...
                                                        1.000000e-05
19
    [[2.7341191226158608], [1.1070301791999142], [...
                                                        1.000000e-06
12
    [[3.6109084400585387], [11.42702526345321], [-...
                                                        1.000000e-04
    [[3.016669053499772], [9.333632805388874], [-1...
24
                                                        1.000000e-06
    [[3.097120568287582], [8.175406022439612], [-1...
22
                                                        1.000000e-06
21
    [[2.7030305464057154], [8.683157932519787], [-...
                                                       1.000000e-06
29
    [[2.989559318463753], [8.044352212204572], [-1...
                                                        1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
11
                                                        1.000000e-03
20
    [[3.0167390363517588], [8.607754261039704], [0...
                                                        1.000000e-06
    [[1.8917011563673924], [3.7425174840678586], [...
8
                                                       1.000000e-06
    [[5.958742925531525], [14.327917968306403], [-...
10
                                                        1.000000e-02
4
    [[9.970728371948313], [26.491694165903258], [-...
                                                       1.000000e-06
```

```
2 [[47.64433276868854], [130.6790054571249], [-1... 1.000000e-06
1 [[95.81933692733199], [262.7825656994754], [-3... 1.000000e-06
3 [[24.070810464619214], [65.46666343519061], [-... 1.000000e-06
9 [[0.000306594212121212], [0.00038259484848484... 1.000000e-06
```

```
elapsed_time is_max_reached
                                                 accuracy_kfold
                                                                       variable
                                          loss
30
            0.049
                                     15.737679
                                                       0.757576
                            False
                                                                             log
27
            0.035
                            False
                                     15.737679
                                                       0.757576
                                                                             log
28
            0.036
                            False
                                     15.629731
                                                       0.756902
                                                                             log
23
                            False
            0.037
                                     15.821280
                                                       0.755556
                                                                             log
25
                            False
            0.051
                                     16.145685
                                                       0.751852
                                                                             log
14
            0.072
                            False
                                     16.436353
                                                       0.751515
                                                                         epsilon
26
            0.070
                            False
                                     16.404716
                                                       0.751515
                                                                             log
6
            0.105
                            False
                                     16.436353
                                                       0.751515
                                                                  learning rate
16
            0.413
                            False
                                     16.097559
                                                       0.751515
                                                                         epsilon
15
            0.166
                            False
                                     16.225842
                                                       0.751178
                                                                         epsilon
17
            0.940
                            False
                                     16.019264
                                                                         epsilon
                                                       0.750842
5
            0.162
                            False
                                     17.234261
                                                       0.750505
                                                                  learning rate
18
            0.048
                            False
                                     16.526437
                                                       0.750168
                                                                             log
0
            0.049
                            False
                                     15.855793
                                                                   all features
                                                       0.749495
7
            0.155
                            False
                                     15.849570
                                                       0.749495
                                                                  learning rate
13
            0.027
                            False
                                     16.775910
                                                       0.749495
                                                                         epsilon
19
            0.023
                            False
                                     16.070200
                                                       0.748485
                                                                             log
12
                            False
                                                       0.747475
            0.013
                                     17.369442
                                                                         epsilon
24
                            False
                                     16.234284
            0.056
                                                       0.747138
                                                                             log
22
            0.069
                            False
                                     16.334522
                                                       0.746465
                                                                             log
                            False
                                     16.245876
21
            0.044
                                                       0.744781
                                                                             log
29
                            False
            0.061
                                     16.176293
                                                       0.744108
                                                                             log
11
            0.009
                            False
                                     18.607920
                                                       0.743771
                                                                         epsilon
20
            0.052
                            False
                                     16.291746
                                                       0.743434
                                                                             log
8
            0.266
                            False
                                     16.462365
                                                       0.741414
                                                                  learning rate
10
            0.009
                            False
                                     21.366778
                                                       0.737037
                                                                         epsilon
4
            6.472
                             True
                                     46.838322
                                                       0.688552
                                                                  learning rate
2
            6.500
                             True
                                   106.221172
                                                       0.683502
                                                                  learning rate
1
           8.592
                             True
                                   118.189617
                                                       0.683165
                                                                  learning rate
3
           8.383
                             True
                                     87.970034
                                                       0.683165
                                                                  learning rate
9
            0.000
                            False
                                     20.585959
                                                       0.516835
                                                                  learning rate
```

show_sorted_model(model_data)

```
0 ,column=> Pregnancies
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Glucose
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> BloodPressure
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
3 ,column=> Heart Rate
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> SkinThickness
```

```
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Insulin
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> BMI
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
7 ,column=> DiabetesPedigreeFunction
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
8 ,column=> Age
i====> 0
i====> 1
i====> 2
i====> 3
```

```
i====> 5
              6
     i====>
     i====> 7
     i====> 8
     i====> 9
[26]:
         model_name
                                                       description
      34
                                    log age-insulin-no Heart Rate
                 kd
      27
                                                   log age-insulin
                 kd
      30
                 kd
                                                   log age-insulin
      28
                 kd
                                               log age-insulin-Dpf
      23
                                                       log Insulin
                 kd
      38
                 kd
                      log age-insulin-no DiabetesPedigreeFunction
      25
                                     log DiabetesPedigreeFunction
                 kd
                                        whole model-epsilon:1e-08
      16
                 kd
      26
                 kd
                                                           log Age
      14
                                        whole model-epsilon:1e-06
                 kd
                       whole model-lr:lr_type.iteration_plus_one
      6
                 kd
      15
                 kd
                                        whole model-epsilon:1e-07
      17
                 kd
                                        whole model-epsilon:1e-09
      31
                                   log age-insulin-no Pregnancies
                 kd
      33
                 kd
                                 log age-insulin-no BloodPressure
      35
                 kd
                                 log age-insulin-no SkinThickness
      5
                 kd
                                 whole model-lr:lr_type.iteration
      18
                                                   log Pregnancies
                 kd
                 kd
                               whole model-lr:lr_type.sample_size
      0
                                                       whole model
                 kd
                                        whole model-epsilon:1e-05
      13
                 kd
      19
                 kd
                                                       log Glucose
      12
                                       whole model-epsilon:0.0001
                 kd
      24
                 kd
                                                           log BMI
      22
                 kd
                                                 log SkinThickness
      37
                 kd
                                           log age-insulin-no BMI
                                                    log Heart Rate
      21
                 kd
      29
                 kd
                                                      log skin-bmi
                 kd
      11
                                        whole model-epsilon:0.001
```

i====> 4

20

8

39

36

10

32

4

2

1

3

kd

whole model-lr:lr_type.ten_sample_size

log BloodPressure

log age-insulin-no Age

whole model-lr:0.05

whole model-lr:0.25

whole model-lr:0.125

whole model-lr:0.5

log age-insulin-no Insulin

log age-insulin-no Glucose

whole model-epsilon:0.01

```
9
           kd
                whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration
34
     lr_type.iteration_plus_one
27
     lr_type.iteration_plus_one
                                        836
30
     lr_type.iteration_plus_one
                                       836
     lr_type.iteration_plus_one
28
                                       742
23
     lr_type.iteration_plus_one
                                       802
38
     lr type.iteration plus one
                                       995
25
     lr_type.iteration_plus_one
                                       1118
16
     lr type.iteration plus one
                                       9021
26
     lr_type.iteration_plus_one
                                       1425
14
     lr_type.iteration_plus_one
                                       1476
6
     lr_type.iteration_plus_one
                                       1476
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
31
     lr_type.iteration_plus_one
                                       877
33
     lr_type.iteration_plus_one
                                       656
35
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                                                                feature removal
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           0.051
                           False
                                    16.145685
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                                                                             log
```

```
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                                                                               log
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                                                       0.751515
                                                                           epsilon
6
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                            False
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                                                       0.751515
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            0.073
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                                                       0.750505
                                                                     learning rate
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                                                                               log
7
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                            False
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                                                                           epsilon
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                                                                                log
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                            False
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                                                                  feature removal
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2
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1
            8.592
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3
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                                     87.970034
                                                                     learning rate
                                                       0.683165
9
                                     20.585959
            0.000
                            False
                                                       0.516835
                                                                     learning rate
```

```
i====> 0
i====> 1
i====> 2
i====> 3
```

```
i====> 5
              6
     i====>
     i====> 7
     i====> 8
     i====> 9
[27]:
         model_name
                                                       description
      40
                                     log age-insulin-no heartrate
                 kd
      34
                                    log age-insulin-no Heart Rate
                 kd
      27
                                                   log age-insulin
                 kd
      30
                 kd
                                                   log age-insulin
      28
                 kd
                                              log age-insulin-Dpf
                                                       log Insulin
      23
                 kd
      38
                     log age-insulin-no DiabetesPedigreeFunction
                 kd
      25
                                     log DiabetesPedigreeFunction
                 kd
      6
                 kd
                        whole model-lr:lr_type.iteration_plus_one
      26
                                                           log Age
                 kd
                                        whole model-epsilon:1e-06
      14
                 kd
      16
                                        whole model-epsilon:1e-08
                                        whole model-epsilon:1e-07
      15
                 kd
      17
                                        whole model-epsilon:1e-09
                 kd
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                                 log age-insulin-no BloodPressure
                 kd
                                   log age-insulin-no Pregnancies
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                 kd
      35
                 kd
                                 log age-insulin-no SkinThickness
      5
                                 whole model-lr:lr_type.iteration
                 kd
      18
                 kd
                                                   log Pregnancies
                                                       whole model
                 kd
      13
                 kd
                                        whole model-epsilon:1e-05
      7
                 kd
                               whole model-lr:lr_type.sample_size
      19
                                                       log Glucose
                 kd
      12
                                       whole model-epsilon:0.0001
                 kd
      24
                 kd
                                                           log BMI
      37
                 kd
                                           log age-insulin-no BMI
      22
                                                 log SkinThickness
                 kd
      21
                 kd
                                                    log Heart Rate
      29
                 kd
                                                      log skin-bmi
                                        whole model-epsilon:0.001
      11
                 kd
      20
                                                 log BloodPressure
                 kd
      8
                           whole model-lr:lr_type.ten_sample_size
                 kd
      39
                                           log age-insulin-no Age
                 kd
      36
                 kd
                                       log age-insulin-no Insulin
      10
                 kd
                                         whole model-epsilon:0.01
```

i====> 4

32

4

2

1

kd

kd

kd

kd

log age-insulin-no Glucose

whole model-lr:0.05

whole model-lr:0.25

whole model-lr:0.5

```
3
           kd
                                        whole model-lr:0.125
9
           kd
                 whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration \
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     lr type.iteration plus one
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     lr type.iteration plus one
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     lr_type.iteration_plus_one
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     lr type.iteration plus one
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18
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0
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7
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12
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     lr_type.iteration_plus_one
24
                                       1341
37
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     lr_type.iteration_plus_one
                                       1008
29
     lr_type.iteration_plus_one
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11
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20
     lr_type.iteration_plus_one
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8
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     lr_type.iteration_plus_one
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10
     lr type.iteration plus one
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32
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4
                            0.05
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2
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1
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                                         loss
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                                                                feature removal
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                           False
                                   15.717127
                                                     0.759933
                                                                feature removal
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           0.035
                           False
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                                                                             log
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           0.049
                           False
                                    15.737679
                                                     0.757576
                                                                             log
```

```
28
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                            False
                                     15.629731
                                                       0.756902
                                                                               log
23
            0.037
                            False
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            0.072
                            False
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                            False
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                                                                                log
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                            False
            0.105
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                                                                     learning rate
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                            False
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                                                                               log
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                            False
                                     16.436353
                                                                           epsilon
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                            False
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                                                       0.751515
                                                                           epsilon
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                            False
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                                                       0.751178
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                                     16.019264
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                                                       0.750842
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                            False
                                     15.788618
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                                                                  feature removal
5
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                            False
                                     17.234261
                                                       0.750505
                                                                     learning rate
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                            False
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                                                       0.747475
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                            False
                                     16.234284
                                                       0.747138
                                                                                log
                            False
37
            0.049
                                     15.701077
                                                       0.746465
                                                                  feature removal
22
            0.069
                                     16.334522
                            False
                                                       0.746465
                                                                               log
                            False
21
            0.044
                                     16.245876
                                                       0.744781
                                                                               log
29
                            False
                                     16.176293
            0.061
                                                       0.744108
                                                                               log
11
            0.009
                            False
                                     18.607920
                                                       0.743771
                                                                           epsilon
                            False
20
            0.052
                                     16.291746
                                                       0.743434
                                                                               log
8
                            False
            0.266
                                     16.462365
                                                       0.741414
                                                                     learning rate
39
            0.061
                            False
                                     15.972236
                                                       0.740067
                                                                  feature removal
36
            0.099
                                     17.179665
                                                       0.739731
                                                                  feature removal
                            False
10
            0.009
                            False
                                     21.366778
                                                       0.737037
                                                                           epsilon
32
            0.035
                            False
                                     17.264986
                                                       0.729630
                                                                  feature removal
4
            6.472
                             True
                                     46.838322
                                                       0.688552
                                                                     learning rate
2
            6.500
                             True
                                    106.221172
                                                       0.683502
                                                                     learning rate
1
            8.592
                             True
                                    118.189617
                                                       0.683165
                                                                    learning rate
3
            8.383
                                     87.970034
                                                                    learning rate
                             True
                                                       0.683165
9
            0.000
                            False
                                     20.585959
                                                       0.516835
                                                                    learning rate
```

```
⇔kd_y_train , model_data = model_data,variable = 'feature *2')
show_sorted_model(model_data)
0 ,column=> Pregnancies
log age-insulin-no heartrate-*2 Pregnancies
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Glucose
log age-insulin-no heartrate-*2 Glucose
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> BloodPressure
log age-insulin-no heartrate-*2 BloodPressure
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
3 ,column=> Heart Rate
log age-insulin-no heartrate-*2 Heart Rate
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
```

epsilon = 1e-6,x_train = kd_x_power , y_train =_

```
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> SkinThickness
log age-insulin-no heartrate-*2 SkinThickness
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Insulin
log age-insulin-no heartrate-*2 Insulin
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> BMI
log age-insulin-no heartrate-*2 BMI
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
7 ,column=> DiabetesPedigreeFunction
log age-insulin-no heartrate-*2 DiabetesPedigreeFunction
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
```

i==== i====	_	
i====		
i====		
i====	==> 9	
[28]: mo	odel_name	description
34	kd	log age-insulin-no Heart Rate
40	kd	log age-insulin-no heartrate
42	kd	log age-insulin-no heartrate-*2 Glucose
43	kd	log age-insulin-no heartrate-*2 BloodPressure
41	kd	log age-insulin-no heartrate-*2 Pregnancies
27	kd	log age-insulin
30	kd	log age-insulin
28	kd	log age-insulin-Dpf
47	kd	log age-insulin-no heartrate-*2 BMI
46	kd	log age-insulin-no heartrate-*2 Insulin
23	kd	log Insulin
38	kd	log age-insulin-no DiabetesPedigreeFunction
25	kd	log DiabetesPedigreeFunction
6	kd	whole model-lr:lr_type.iteration_plus_one
26	kd	log Age
14	kd	whole model-epsilon:1e-06
16	kd	whole model-epsilon:1e-08
15	kd	whole model-epsilon:1e-07
17	kd	whole model-epsilon:1e-09
33	kd	log age-insulin-no BloodPressure
31	kd	log age-insulin-no Pregnancies
35	kd	log age-insulin-no SkinThickness
5	kd	whole model-lr:lr_type.iteration
44	kd	log age-insulin-no heartrate-*2 Heart Rate
18	kd	log Pregnancies
13	kd	whole model-epsilon:1e-05
7	kd	whole model-lr:lr_type.sample_size
0	kd	whole model ii.ii_uype.sample_size whole model
19	kd	log Glucose
12	kd	whole model-epsilon:0.0001
24	kd	log BMI
37	kd	log age-insulin-no BMI
22	kd	log SkinThickness
21	kd	log Heart Rate
29	kd	log skin-bmi
11	kd	whole model-epsilon:0.001
48		log age-insulin-no heartrate-*2 DiabetesPedigr
20	kd	log BloodPressure
8	kd	whole model-lr:lr_type.ten_sample_size
39	kd	log age-insulin-no Age
38	ĸu	TOR TRE-THEMITHEN WAS

```
36
           kd
                                        log age-insulin-no Insulin
10
           kd
                                          whole model-epsilon:0.01
                    log age-insulin-no heartrate-*2 SkinThickness
45
           kd
32
           kd
                                        log age-insulin-no Glucose
4
           kd
                                               whole model-lr:0.05
2
           kd
                                               whole model-lr:0.25
           kd
                                                whole model-lr:0.5
1
3
           kd
                                              whole model-lr:0.125
9
           kd
                       whole model-lr:lr type.hundred sample size
                  learning_rate iteration \
34
     lr_type.iteration_plus_one
                                        813
     lr type.iteration plus one
40
                                        813
42
     lr_type.iteration_plus_one
                                        706
43
     lr_type.iteration_plus_one
                                        702
41
     lr_type.iteration_plus_one
                                        832
27
     lr_type.iteration_plus_one
                                        836
     lr_type.iteration_plus_one
30
                                        836
28
     lr_type.iteration_plus_one
                                        742
47
     lr_type.iteration_plus_one
                                        938
46
     lr_type.iteration_plus_one
                                        741
23
     lr type.iteration plus one
                                        802
38
     lr_type.iteration_plus_one
                                        995
25
     lr type.iteration plus one
                                       1118
6
     lr type.iteration plus one
                                       1476
26
     lr type.iteration plus one
                                       1425
     lr_type.iteration_plus_one
14
                                       1476
16
     lr type.iteration plus one
                                       9021
     lr_type.iteration_plus_one
15
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
33
     lr_type.iteration_plus_one
                                        656
31
     lr_type.iteration_plus_one
                                        877
35
     lr_type.iteration_plus_one
                                        987
5
              lr_type.iteration
                                       2220
44
     lr_type.iteration_plus_one
                                        834
18
     lr_type.iteration_plus_one
                                       1129
13
     lr_type.iteration_plus_one
                                        636
7
            lr_type.sample_size
                                       2048
0
                                        956
                            0.01
19
     lr_type.iteration_plus_one
                                        560
12
     lr type.iteration plus one
                                        314
24
     lr_type.iteration_plus_one
                                       1341
37
     lr_type.iteration_plus_one
                                        711
22
     lr_type.iteration_plus_one
                                       1075
21
     lr_type.iteration_plus_one
                                       1008
29
                                        978
     lr_type.iteration_plus_one
     lr_type.iteration_plus_one
                                        165
11
```

```
48
     lr_type.iteration_plus_one
                                       1274
20
     lr type.iteration plus one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
39
     lr_type.iteration_plus_one
                                        790
     lr_type.iteration_plus_one
36
                                       1293
10
     lr_type.iteration_plus_one
                                         84
45
     lr_type.iteration_plus_one
                                       1507
32
     lr_type.iteration_plus_one
                                        484
4
                            0.05
                                     150000
2
                            0.25
                                    150000
1
                             0.5
                                    150000
3
                                    150000
                           0.125
9
    lr type.hundred sample size
                                          2
                                                weights
                                                               epsilon \
    [[2.7129340471248065], [8.273684993858577], [-...
34
                                                        1.000000e-06
    [[2.7129340471248065], [8.273684993858577], [-...
40
                                                        1.000000e-06
    [[2.7707684939995394], [5.782931625664704], [-...
42
                                                        1.000000e-06
    [[2.6840445568619615], [8.100362853592744], [-...
43
                                                       1.000000e-06
    [[3.7667195356425127], [8.238912283417783], [-...
41
                                                        1.000000e-06
    [[2.7683606646024232], [8.122909449757739], [-...
27
                                                        1.000000e-06
30
    [[2.7683606646024232], [8.122909449757739], [-...
                                                        1.000000e-06
28
    [[2.81722351586145], [8.11597903143088], [-0.8...
                                                        1.000000e-06
    [[3.1911630539778977], [8.668229576381282], [-...
47
                                                        1.000000e-06
    [[2.5822636064767592], [7.952642108792551], [-...
46
                                                        1.000000e-06
23
    [[2.686500388124719], [8.005602930239544], [-0...
                                                       1.000000e-06
38
    [[3.528294663986213], [8.888662016489207], [-0...
                                                        1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                        1.000000e-06
6
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
    [[3.2317379647520714], [9.47235968785085], [-1...
26
                                                        1.000000e-06
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                        1.000000e-06
    [[2.96533714092659], [8.33217514426845], [-1.0...
16
                                                        1.000000e-08
    [[3.0601381991207917], [8.83862515342757], [-1...
15
                                                        1.000000e-07
17
    [[2.887385852612343], [7.9553323804450375], [-...
                                                        1.000000e-09
33
    [[2.726699034298592], [7.741999408211606], [-0...
                                                        1.000000e-06
31
    [[7.954655592251466], [-1.0448422866347953], [...
                                                        1.000000e-06
    [[2.8454163866127455], [7.444158178181417], [-...
35
                                                        1.000000e-06
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
    [[2.724842549802258], [8.017986056469372], [-1...
44
                                                        1.000000e-06
    [[0.47048312539781034], [8.606990965621858], [...
18
                                                        1.000000e-06
    [[3.3327577160627104], [10.39377495841507], [-...
13
                                                        1.000000e-05
7
    [[2.5011580589018196], [6.514304926750582], [-...
                                                        1.000000e-06
    [[2.5819277747484066], [6.780007402086465], [-...
0
                                                        1.000000e-06
    [[2.7341191226158608], [1.1070301791999142], [...
19
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
12
                                                       1.000000e-04
    [[3.016669053499772], [9.333632805388874], [-1...
24
                                                        1.000000e-06
37
    [[2.5109910019024677], [7.816325231383992], [-...
                                                       1.000000e-06
```

```
22
    [[3.097120568287582], [8.175406022439612], [-1... 1.000000e-06
    [[2.7030305464057154], [8.683157932519787], [-...
21
                                                       1.000000e-06
29
    [[2.989559318463753], [8.044352212204572], [-1...
                                                       1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
11
                                                       1.000000e-03
    [[2.8730033537390356], [8.894450845054584], [-...
                                                       1.000000e-06
48
    [[3.0167390363517588], [8.607754261039704], [0...
20
                                                       1.000000e-06
    [[1.8917011563673924], [3.7425174840678586], [...
8
                                                       1.000000e-06
    [[2.5616285768893263], [7.794299182419026], [-...
39
                                                       1.000000e-06
    [[2.820836202474606], [9.936728220495777], [-0...
36
                                                       1.000000e-06
    [[5.958742925531525], [14.327917968306403], [-...
10
                                                       1.000000e-02
    [[2.8269443408264547], [10.095837895438326], [...
45
                                                       1.000000e-06
32
    [[2.360917183337187], [-0.8182987407890269], [...
                                                      1.000000e-06
4
    [[9.970728371948313], [26.491694165903258], [-...
                                                      1.000000e-06
2
    [[47.64433276868854], [130.6790054571249], [-1...
                                                       1.000000e-06
    [[95.81933692733199], [262.7825656994754], [-3...
1
                                                      1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-... 1.000000e-06
3
    [[0.0003065942121212121], [0.00038259484848484... 1.000000e-06
9
```

	elapsed_time	is_max_reached	loss	accuracy_kfold	variable
34	0.062	False	15.717127	0.759933	feature removal
40	0.045	False	15.717127	0.759933	feature removal
42	0.032	False	15.705729	0.758586	feature *2
43	0.033	False	15.651793	0.758249	feature *2
41	0.046	False	15.915845	0.758249	feature *2
27	0.035	False	15.737679	0.757576	log
30	0.049	False	15.737679	0.757576	log
28	0.036	False	15.629731	0.756902	log
47	0.039	False	15.849282	0.756566	feature *2
46	0.031	False	15.840965	0.755556	feature *2
23	0.037	False	15.821280	0.755556	log
38	0.072	False	15.632706	0.751852	feature removal
25	0.051	False	16.145685	0.751852	log
6	0.105	False	16.436353	0.751515	learning rate
26	0.070	False	16.404716	0.751515	log
14	0.072	False	16.436353	0.751515	epsilon
16	0.413	False	16.097559	0.751515	epsilon
15	0.166	False	16.225842	0.751178	epsilon
17	0.940	False	16.019264	0.750842	epsilon
33	0.046	False	15.583091	0.750842	feature removal
31	0.041	False	16.310581	0.750842	feature removal
35	0.073	False	15.788618	0.750505	feature removal
5	0.162	False	17.234261	0.750505	learning rate
44	0.036	False	15.823767	0.750168	feature *2
18	0.048	False	16.526437	0.750168	log
13	0.027	False	16.775910	0.749495	epsilon
7	0.155	False	15.849570	0.749495	learning rate
0	0.049	False	15.855793	0.749495	all features

```
19
           0.023
                           False
                                    16.070200
                                                       0.748485
                                                                              log
12
           0.013
                            False
                                    17.369442
                                                       0.747475
                                                                          epsilon
24
           0.056
                            False
                                    16.234284
                                                       0.747138
                                                                              log
37
           0.049
                            False
                                    15.701077
                                                       0.746465
                                                                 feature removal
22
           0.069
                           False
                                    16.334522
                                                       0.746465
                                                                              log
21
           0.044
                           False
                                    16.245876
                                                       0.744781
                                                                              log
29
           0.061
                            False
                                    16.176293
                                                       0.744108
                                                                              log
                           False
11
           0.009
                                    18.607920
                                                       0.743771
                                                                          epsilon
48
                                                                       feature *2
           0.055
                           False
                                    16.098061
                                                       0.743771
20
           0.052
                           False
                                    16.291746
                                                       0.743434
                                                                              log
                           False
8
           0.266
                                    16.462365
                                                       0.741414
                                                                   learning rate
39
           0.061
                           False
                                    15.972236
                                                       0.740067
                                                                 feature removal
36
           0.099
                           False
                                    17.179665
                                                       0.739731
                                                                 feature removal
10
           0.009
                           False
                                    21.366778
                                                       0.737037
                                                                          epsilon
45
           0.066
                           False
                                    17.222705
                                                       0.735690
                                                                       feature *2
32
           0.035
                            False
                                    17.264986
                                                       0.729630
                                                                 feature removal
4
           6.472
                             True
                                    46.838322
                                                                    learning rate
                                                       0.688552
2
                                   106.221172
           6.500
                             True
                                                       0.683502
                                                                   learning rate
1
           8.592
                             True
                                   118.189617
                                                       0.683165
                                                                   learning rate
3
           8.383
                             True
                                    87.970034
                                                       0.683165
                                                                   learning rate
9
           0.000
                            False
                                    20.585959
                                                       0.516835
                                                                   learning rate
```

[29]: #model_data.tail(1)
 #model_data.drop(model_data.tail(1).index,inplace=True) # drop last n rows
 show_sorted_model(model_data)

•	description	model_name	[29]:
	log age-insulin-no Heart Rate	kd	34
	log age-insulin-no heartrate	kd	40
	log age-insulin-no heartrate-*2 Glucose	kd	42
	log age-insulin-no heartrate-*2 BloodPressure	kd	43
	log age-insulin-no heartrate-*2 Pregnancies	kd	41
	log age-insulin	kd	27
	log age-insulin	kd	30
	log age-insulin-Dpf	kd	28
	log age-insulin-no heartrate-*2 BMI	kd	47
	log age-insulin-no heartrate-*2 Insulin	kd	46
	log Insulin	kd	23
	log age-insulin-no DiabetesPedigreeFunction	kd	38
	log DiabetesPedigreeFunction	kd	25
	whole model-lr:lr_type.iteration_plus_one	kd	6
	log Age	kd	26
	whole model-epsilon:1e-06	kd	14
	whole model-epsilon:1e-08	kd	16
	whole model-epsilon:1e-07	kd	15
	whole model-epsilon:1e-09	kd	17
	log age-insulin-no BloodPressure	kd	33

```
31
           kd
                                   log age-insulin-no Pregnancies
35
           kd
                                 log age-insulin-no SkinThickness
5
           kd
                                 whole model-lr:lr_type.iteration
44
           kd
                       log age-insulin-no heartrate-*2 Heart Rate
18
                                                   log Pregnancies
           kd
13
                                         whole model-epsilon:1e-05
           kd
7
           kd
                               whole model-lr:lr_type.sample_size
0
                                                       whole model
           kd
19
                                                       log Glucose
           kd
12
           kd
                                        whole model-epsilon:0.0001
24
                                                            log BMI
           kd
37
           kd
                                            log age-insulin-no BMI
22
           kd
                                                 log SkinThickness
21
           kd
                                                    log Heart Rate
29
           kd
                                                      log skin-bmi
11
           kd
                                         whole model-epsilon:0.001
48
           kd
                log age-insulin-no heartrate-*2 DiabetesPedigr...
20
           kd
                                                 log BloodPressure
8
           kd
                           whole model-lr:lr_type.ten_sample_size
                                            log age-insulin-no Age
39
           kd
36
           kd
                                        log age-insulin-no Insulin
10
                                          whole model-epsilon:0.01
           kd
45
           kd
                    log age-insulin-no heartrate-*2 SkinThickness
32
           kd
                                        log age-insulin-no Glucose
4
           kd
                                               whole model-lr:0.05
2
           kd
                                               whole model-lr:0.25
                                                whole model-lr:0.5
1
           kd
3
           kd
                                              whole model-lr:0.125
9
           kd
                       whole model-lr:lr_type.hundred_sample_size
                   learning_rate iteration
34
     lr_type.iteration_plus_one
                                        813
40
     lr_type.iteration_plus_one
                                        813
42
     lr_type.iteration_plus_one
                                        706
43
     lr_type.iteration_plus_one
                                        702
41
     lr_type.iteration_plus_one
                                        832
27
     lr_type.iteration_plus_one
                                        836
30
     lr_type.iteration_plus_one
                                        836
28
     lr type.iteration plus one
                                        742
47
     lr_type.iteration_plus_one
                                       938
46
                                        741
     lr_type.iteration_plus_one
     lr_type.iteration_plus_one
23
                                        802
38
     lr_type.iteration_plus_one
                                       995
25
     lr_type.iteration_plus_one
                                       1118
     lr_type.iteration_plus_one
                                       1476
6
26
     lr_type.iteration_plus_one
                                       1425
14
     lr_type.iteration_plus_one
                                       1476
```

```
9021
16
     lr_type.iteration_plus_one
     lr_type.iteration_plus_one
                                      3643
15
17
     lr_type.iteration_plus_one
                                     22164
33
     lr_type.iteration_plus_one
                                       656
31
     lr_type.iteration_plus_one
                                       877
35
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     lr type.iteration plus one
                                      1129
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13
     lr_type.iteration_plus_one
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19
     lr type.iteration plus one
                                       560
12
     lr_type.iteration_plus_one
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24
     lr_type.iteration_plus_one
                                      1341
37
     lr_type.iteration_plus_one
                                       711
     lr_type.iteration_plus_one
22
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21
     lr_type.iteration_plus_one
                                      1008
29
     lr_type.iteration_plus_one
                                       978
11
     lr_type.iteration_plus_one
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48
     lr_type.iteration_plus_one
                                      1274
20
     lr type.iteration plus one
                                      1045
8
        lr_type.ten_sample_size
                                      3516
39
     lr type.iteration plus one
                                       790
36
     lr type.iteration plus one
                                      1293
10
     lr type.iteration plus one
                                        84
45
     lr_type.iteration_plus_one
                                      1507
32
     lr type.iteration plus one
                                       484
4
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                                    150000
2
                            0.25
                                    150000
1
                             0.5
                                    150000
3
                                    150000
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                                         loss
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                                    15.717127
                                                      0.759933
                                                                feature removal
40
           0.045
                           False
                                    15.717127
                                                      0.759933
                                                                feature removal
42
           0.032
                           False
                                    15.705729
                                                      0.758586
                                                                      feature *2
43
           0.033
                           False
                                    15.651793
                                                                      feature *2
                                                      0.758249
41
           0.046
                           False
                                    15.915845
                                                      0.758249
                                                                      feature *2
27
                           False
           0.035
                                    15.737679
                                                      0.757576
                                                                             log
30
           0.049
                           False
                                    15.737679
                                                      0.757576
                                                                             log
28
           0.036
                           False
                                    15.629731
                                                      0.756902
                                                                             log
```

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1.000000e-06

1.000000e-06

25

6

```
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                            False
                                     15.849282
                                                                        feature *2
46
            0.031
                            False
                                     15.840965
                                                        0.755556
                                                                        feature *2
23
            0.037
                            False
                                     15.821280
                                                        0.755556
                                                                                log
38
            0.072
                            False
                                     15.632706
                                                        0.751852
                                                                   feature removal
25
            0.051
                            False
                                     16.145685
                                                        0.751852
                                                                                log
                                                                     learning rate
6
            0.105
                            False
                                     16.436353
                                                        0.751515
26
            0.070
                            False
                                     16.404716
                                                        0.751515
                                                                                log
                                                                           epsilon
14
            0.072
                            False
                                     16.436353
                                                        0.751515
                                                                           epsilon
16
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                            False
                                     16.097559
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            0.166
                            False
                                     16.225842
                                                        0.751178
                                                                           epsilon
                            False
17
            0.940
                                     16.019264
                                                        0.750842
                                                                           epsilon
33
            0.046
                            False
                                     15.583091
                                                        0.750842
                                                                   feature removal
31
            0.041
                            False
                                     16.310581
                                                        0.750842
                                                                   feature removal
35
            0.073
                            False
                                     15.788618
                                                        0.750505
                                                                   feature removal
5
            0.162
                            False
                                     17.234261
                                                        0.750505
                                                                     learning rate
44
            0.036
                            False
                                     15.823767
                                                        0.750168
                                                                        feature *2
18
            0.048
                            False
                                     16.526437
                                                        0.750168
                                                                                log
                                     16.775910
13
            0.027
                            False
                                                        0.749495
                                                                           epsilon
7
            0.155
                            False
                                     15.849570
                                                        0.749495
                                                                     learning rate
0
            0.049
                            False
                                     15.855793
                                                                      all features
                                                        0.749495
19
            0.023
                            False
                                     16.070200
                                                        0.748485
                                                                                log
                                     17.369442
12
                            False
            0.013
                                                        0.747475
                                                                           epsilon
24
            0.056
                            False
                                     16.234284
                                                        0.747138
                                                                                log
37
                            False
            0.049
                                     15.701077
                                                        0.746465
                                                                   feature removal
22
            0.069
                            False
                                     16.334522
                                                        0.746465
                                                                                log
21
            0.044
                            False
                                     16.245876
                                                        0.744781
                                                                                log
                            False
29
            0.061
                                     16.176293
                                                        0.744108
                                                                                log
11
                            False
                                     18.607920
            0.009
                                                        0.743771
                                                                           epsilon
48
            0.055
                            False
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                                                                        feature *2
20
                                     16.291746
            0.052
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                                                                                log
8
            0.266
                            False
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39
            0.061
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10
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                                                        0.737037
                                                                           epsilon
45
            0.066
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                                                                        feature *2
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32
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                                                        0.729630
                                                                   feature removal
4
            6.472
                                     46.838322
                             True
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2
            6.500
                             True
                                    106.221172
                                                                     learning rate
                                                        0.683502
1
            8.592
                             True
                                    118.189617
                                                        0.683165
                                                                     learning rate
3
                                     87.970034
                                                                     learning rate
            8.383
                             True
                                                        0.683165
9
            0.000
                            False
                                     20.585959
                                                        0.516835
                                                                     learning rate
```

```
[30]: #check power 3 of features
for i in range(kd_x_train_features.shape[1]):
    print (i,',column=>',kd_columns[i])
    kd_x_power = power_n_feature(pd.DataFrame(kd_x_train_features),i,3).
    sto_numpy()
```

```
title = 'log age-insulin-no heartrate-*3 {}'.format(kd_columns[i])
    print(title)
    model_data = run_model('kd', title, learning_rate = 0, learning_rate_type = u
 Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                     epsilon = 1e-6,x_train = kd_x_power , y_train =
 show_sorted_model(model_data)
0 ,column=> Pregnancies
log age-insulin-no heartrate-*3 Pregnancies
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Glucose
log age-insulin-no heartrate-*3 Glucose
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> BloodPressure
log age-insulin-no heartrate-*3 BloodPressure
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
3 ,column=> Heart Rate
log age-insulin-no heartrate-*3 Heart Rate
```

i====> 0

```
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> SkinThickness
log age-insulin-no heartrate-*3 SkinThickness
i====> 0
i====> 1
i====> 2
i====> 3
<ipython-input-8-caf8b4b6b9cd>:100: RuntimeWarning: overflow encountered in exp
 return 1 / (1 + np.exp(-arg))
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Insulin
log age-insulin-no heartrate-*3 Insulin
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> BMI
log age-insulin-no heartrate-*3 BMI
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
```

```
7 ,column=> DiabetesPedigreeFunction
     log age-insulin-no heartrate-*3 DiabetesPedigreeFunction
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[30]:
         model_name
                                                            description
      53
                         log age-insulin-no heartrate-*3 SkinThickness
                 kd
      49
                 kd
                           log age-insulin-no heartrate-*3 Pregnancies
      40
                 kd
                                          log age-insulin-no heartrate
      34
                                          log age-insulin-no Heart Rate
                 kd
     50
                 kd
                               log age-insulin-no heartrate-*3 Glucose
      42
                 kd
                               log age-insulin-no heartrate-*2 Glucose
      43
                 kd
                         log age-insulin-no heartrate-*2 BloodPressure
      41
                 kd
                           log age-insulin-no heartrate-*2 Pregnancies
     27
                 kd
                                                        log age-insulin
      30
                                                        log age-insulin
                 kd
      28
                 kd
                                                    log age-insulin-Dpf
      47
                                   log age-insulin-no heartrate-*2 BMI
                 kd
      51
                 kd
                         log age-insulin-no heartrate-*3 BloodPressure
                               log age-insulin-no heartrate-*2 Insulin
     46
                 kd
      23
                 kd
                                                            log Insulin
     55
                 kd
                                   log age-insulin-no heartrate-*3 BMI
     25
                                          log DiabetesPedigreeFunction
                 kd
                           log age-insulin-no DiabetesPedigreeFunction
     38
                 kd
      16
                 kd
                                              whole model-epsilon:1e-08
      14
                                              whole model-epsilon:1e-06
                 kd
                             whole model-lr:lr_type.iteration_plus_one
                 kd
      26
                 kd
                                                                log Age
      15
                 kd
                                              whole model-epsilon:1e-07
                                              whole model-epsilon:1e-09
      17
                 kd
      33
                                      log age-insulin-no BloodPressure
                 kd
     31
                                        log age-insulin-no Pregnancies
                 kd
      35
                 kd
                                      log age-insulin-no SkinThickness
     5
                 kd
                                      whole model-lr:lr_type.iteration
      44
                 kd
                            log age-insulin-no heartrate-*2 Heart Rate
      18
                 kd
                                                        log Pregnancies
                                                            whole model
      0
                 kd
                                              whole model-epsilon:1e-05
      13
                 kd
     7
                 kd
                                    whole model-lr:lr_type.sample_size
```

```
52
           kd
                       log age-insulin-no heartrate-*3 Heart Rate
19
           kd
                                                        log Glucose
12
           kd
                                        whole model-epsilon:0.0001
24
           kd
                                                            log BMI
54
           kd
                          log age-insulin-no heartrate-*3 Insulin
22
                                                 log SkinThickness
           kd
37
           kd
                                            log age-insulin-no BMI
21
           kd
                                                    log Heart Rate
29
           kd
                                                       log skin-bmi
11
           kd
                                         whole model-epsilon:0.001
48
                log age-insulin-no heartrate-*2 DiabetesPedigr...
           kd
20
           kd
                                                 log BloodPressure
           kd
                           whole model-lr:lr_type.ten_sample_size
39
                                            log age-insulin-no Age
           kd
36
                                        log age-insulin-no Insulin
           kd
56
           kd
                log age-insulin-no heartrate-*3 DiabetesPedigr...
10
           kd
                                          whole model-epsilon:0.01
45
           kd
                    log age-insulin-no heartrate-*2 SkinThickness
32
           kd
                                        log age-insulin-no Glucose
4
           kd
                                               whole model-lr:0.05
2
           kd
                                               whole model-lr:0.25
1
           kd
                                                whole model-lr:0.5
3
           kd
                                              whole model-lr:0.125
9
           kd
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53
49
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34
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                                        813
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                                        706
     lr_type.iteration_plus_one
43
                                        702
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                                        832
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     lr_type.iteration_plus_one
                                        836
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                                        938
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     lr type.iteration plus one
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                                        741
23
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                                        959
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                                        995
16
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                                       9021
14
     lr_type.iteration_plus_one
                                       1476
6
     lr_type.iteration_plus_one
                                       1476
```

```
1425
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     lr_type.iteration_plus_one
     lr_type.iteration_plus_one
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31
     lr_type.iteration_plus_one
                                       877
35
     lr_type.iteration_plus_one
                                       987
5
              lr_type.iteration
                                      2220
44
     lr_type.iteration_plus_one
                                       834
18
     lr type.iteration plus one
                                      1129
0
                                       956
13
     lr_type.iteration_plus_one
                                       636
7
            lr_type.sample_size
                                      2048
52
     lr type.iteration plus one
                                       893
19
     lr_type.iteration_plus_one
                                       560
12
     lr_type.iteration_plus_one
                                       314
24
     lr_type.iteration_plus_one
                                      1341
     lr_type.iteration_plus_one
54
                                       750
22
     lr_type.iteration_plus_one
                                      1075
     lr_type.iteration_plus_one
37
                                       711
21
     lr_type.iteration_plus_one
                                      1008
29
     lr_type.iteration_plus_one
                                       978
11
     lr type.iteration plus one
                                       165
48
     lr_type.iteration_plus_one
                                      1274
20
     lr type.iteration plus one
                                      1045
8
        lr type.ten sample size
                                      3516
39
     lr type.iteration plus one
                                       790
36
     lr_type.iteration_plus_one
                                      1293
56
     lr_type.iteration_plus_one
                                      1714
10
     lr_type.iteration_plus_one
                                        84
45
     lr_type.iteration_plus_one
                                      1507
32
     lr_type.iteration_plus_one
                                       484
4
                                    150000
                            0.05
2
                            0.25
                                    150000
1
                             0.5
                                    150000
3
                           0.125
                                    150000
9
    lr_type.hundred_sample_size
                                         2
                                                weights
                                                               epsilon \
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27
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```

	elapsed_time	is_max_reached	loss	accuracy_kfold	variable
53	0.058	False	15.777801	0.773737	feature *3
49	0.043	False	16.092013	0.761279	feature *3
40	0.045	False	15.717127	0.759933	feature removal
34	0.062	False	15.717127	0.759933	feature removal
50	0.035	False	15.784424	0.758923	feature *3
42	0.032	False	15.705729	0.758586	feature *2
43	0.033	False	15.651793	0.758249	feature *2
41	0.046	False	15.915845	0.758249	feature *2
27	0.035	False	15.737679	0.757576	log
30	0.049	False	15.737679	0.757576	log
28	0.036	False	15.629731	0.756902	log
47	0.039	False	15.849282	0.756566	feature *2
51	0.039	False	15.634238	0.756229	feature *3
46	0.031	False	15.840965	0.755556	feature *2
23	0.037	False	15.821280	0.755556	log
55	0.045	False	15.814899	0.755219	feature *3
25	0.051	False	16.145685	0.751852	log
38	0.072	False	15.632706	0.751852	feature removal
16	0.413	False	16.097559	0.751515	epsilon
14	0.072	False	16.436353	0.751515	epsilon
6	0.105	False	16.436353	0.751515	learning rate
26	0.070	False	16.404716	0.751515	log
15	0.166	False	16.225842	0.751178	epsilon
17	0.940	False	16.019264	0.750842	epsilon
33	0.046	False	15.583091	0.750842	feature removal
31	0.041	False	16.310581	0.750842	feature removal
35	0.073	False	15.788618	0.750505	feature removal
5	0.162	False	17.234261	0.750505	learning rate
44	0.036	False	15.823767	0.750168	feature *2
18	0.048	False	16.526437	0.750168	log
0	0.049	False	15.855793	0.749495	all features
13	0.027	False	16.775910	0.749495	epsilon
7	0.155	False	15.849570	0.749495	learning rate
52	0.044	False	15.929618	0.748822	feature *3
19	0.023	False	16.070200	0.748485	log
12	0.013	False	17.369442	0.747475	epsilon
24	0.056	False	16.234284	0.747138	log
54	0.036	False	15.882348	0.746801	feature *3
22	0.069	False	16.334522	0.746465	log
37	0.049	False	15.701077	0.746465	feature removal
21	0.044	False	16.245876	0.744781	log
29	0.061	False	16.176293	0.744108	log
11	0.009	False	18.607920	0.743771	epsilon
48	0.055	False	16.098061	0.743771	feature *2

```
20
                 0.052
                                False
                                         16.291746
                                                          0.743434
                                                                                 log
                 0.266
      8
                                False
                                         16.462365
                                                          0.741414
                                                                       learning rate
      39
                 0.061
                                False
                                         15.972236
                                                          0.740067
                                                                    feature removal
      36
                 0.099
                                False
                                        17.179665
                                                          0.739731
                                                                    feature removal
                 0.081
                                False
                                        16.352570
                                                          0.739394
                                                                          feature *3
      56
      10
                 0.009
                                False
                                        21.366778
                                                          0.737037
                                                                             epsilon
      45
                 0.066
                                False
                                       17.222705
                                                          0.735690
                                                                          feature *2
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                 0.035
                                False
                                        17.264986
                                                          0.729630
                                                                    feature removal
      4
                                                                       learning rate
                 6.472
                                 True
                                        46.838322
                                                          0.688552
      2
                 6.500
                                 True 106.221172
                                                                       learning rate
                                                          0.683502
                                                                      learning rate
      1
                 8.592
                                 True 118.189617
                                                          0.683165
      3
                 8.383
                                 True
                                        87.970034
                                                          0.683165
                                                                      learning rate
                 0.000
                                False
                                         20.585959
                                                          0.516835
                                                                      learning rate
[31]: (model data.sort values(by=['accuracy kfold'], ascending=False)).

sto_csv('kidney_disease_models.csv', index=False)
[32]: import os
      cwd = os.getcwd()
      print(cwd)
     /content
[33]: def recursive_feature_elimination(X, y, model, num_features):
          num_samples, num_total_features = X.shape
          # Initialize the mask to include all features
          mask = np.ones(num_total_features, dtype=bool)
          def rfe(X, y, model, mask, num_features):
              if np.sum(mask) == num_features:
                  return X[:, mask]
              model.fit(X[:, mask], y)
              feature_importances = np.zeros(num_total_features)
              feature_importances[mask] = model.feature_importances_
              least_important_feature_idx = np.argmin(feature_importances)
              mask[least important feature idx] = False
              return rfe(X, y, model, mask, num_features)
          return rfe(X, y, model, mask, num_features)
      (model_data.sort_values(by=['accuracy_kfold'], ascending=False))
[34]:
[34]:
         model_name
                                                            description \
      53
                 kd
                         log age-insulin-no heartrate-*3 SkinThickness
```

40 kd log age-insulin-no Heart Rate 50 kd log age-insulin-no Heart Rate 50 kd log age-insulin-no heartrate+3 Glucose 42 kd log age-insulin-no heartrate+2 Glucose 43 kd log age-insulin-no heartrate-*2 Pregnancies 41 kd log age-insulin-no heartrate-*2 Pregnancies 7 kd log age-insulin-no heartrate-*2 Pregnancies 8 kd log age-insulin-no heartrate-*2 BMI 8 kd log age-insulin-no heartrate-*2 BMI 9 kd log age-insulin-no heartrate-*2 Insulin 10 kd log age-insulin-no heartrate-*2 Insulin 10 kd log age-insulin-no heartrate-*3 BMI 10 kd whole model-epsilon:1e-03 10 kd whole model-epsilon:1e-03 10 kd whole model-epsilon:1e-03 10 kd whole model-epsilon:1e-07 10 k	4.0		
34kdlog age-insulin-no heartrate-*3 Glucose42kdlog age-insulin-no heartrate-*2 Glucose43kdlog age-insulin-no heartrate-*2 BloodPressure41kdlog age-insulin-no heartrate-*2 Pregnancies27kdlog age-insulin30kdlog age-insulin-no heartrate-*2 Pregnancies27kdlog age-insulin-no heartrate-*2 Pregnancies28kdlog age-insulin-no heartrate-*2 BMI47kdlog age-insulin-no heartrate-*2 BMI51kdlog age-insulin-no heartrate-*2 Insulin23kdlog age-insulin-no heartrate-*3 BMI25kdlog age-insulin-no DiabetesPedigreeFunction36kdlog age-insulin-no DiabetesPedigreeFunction36kdlog age-insulin-no DiabetesPedigreeFunction36kdwhole model-epsilon:1e-0344kdwhole model-epsilon:1e-066kdwhole model-epsilon:1e-0747kdwhole model-epsilon:1e-0748dlog age-insulin-no BloodPressure35kdlog age-insulin-no SkinThickness5kdlog age-insulin-no heartrate-*2 Heart Rate44kdlog age-insulin-no heartrate-*3 Heart Rate45kdwhole model-lepsilon:1e-057kdwhole model-epsilon:0.00144kdlog age-insulin-no heartrate-*3 Insulin25kdlog age-insulin-no heartrate-*3 Insulin26kdwhole model-epsilon:0.00127k	49	kd	log age-insulin-no heartrate-*3 Pregnancies
50kdlog age-insulin-no heartrate-*3 Glucose42kdlog age-insulin-no heartrate-*2 Glucose43kdlog age-insulin-no heartrate-*2 PloodPressure41kdlog age-insulin50kdlog age-insulin28kdlog age-insulin-Dpf47kdlog age-insulin-no heartrate-*2 BmJ51kdlog age-insulin-no heartrate-*2 BmJ51kdlog age-insulin-no heartrate-*3 BloodPressure46kdlog age-insulin-no heartrate-*2 BmJ23kdlog DiabetesPedigreeFunction45kdlog DiabetesPedigreeFunction46kdlog DiabetesPedigreeFunction46kdwhole model-epsilon:1e-0346kdwhole model-epsilon:1e-0646kdwhole model-epsilon:1e-0646kdwhole model-epsilon:1e-0746kdwhole model-epsilon:1e-0933kdlog age-insulin-no BloodPressure31kdlog age-insulin-no Pregnancies35kdlog age-insulin-no Pregnancies44kdlog age-insulin-no Pregnancies44kdlog age-insulin-no heartrate-*2 Heart Rate18kdwhole model-lr:lr_type.iteration44kdlog age-insulin-no heartrate-*3 Heart Rate18kdwhole model-epsilon:0.000144kdlog Glucose45kdlog Glucose46kdlog SkinThickness37kdlog BloodPress		kd	
42 kd log age-insulin-no heartrate-*2 Glucose 43 kd log age-insulin-no heartrate-*2 Pregnancies 27 kd log age-insulin-no 30 kd log age-insulin-no 28 kd log age-insulin-no 47 kd log age-insulin-no heartrate-*2 BMI 51 kd log age-insulin-no heartrate-*3 BloodPressure 46 kd log JiabetesPedigreeFunction 48 kd log DiabetesPedigreeFunction 49 kd log age-insulin-no heartrate-*3 BMI 55 kd log age-insulin-no heartrate-*3 BMI 55 kd log age-insulin-no heartrate-*2 Insulin 68 kd log DiabetesPedigreeFunction 88 kd log age-insulin-no heartrate-*3 BMI 56 kd whole model-epsilon:1e-08 84 kd whole model-epsilon:1e-08 84 kd whole model-epsilon:1e-07 85 kd log age-insulin-no BloodPressure 85 kd log age-insulin-no SkinThickness 86 kd log age-insulin-no SkinThickness	34	kd	log age-insulin-no Heart Rate
43 kd log age-insulin-no heartrate-*2 BloodPressure 41 kd log age-insulin-no heartrate-*2 Pregnancies 27 kd log age-insulin-log age-insulin-Dpf 30 kd log age-insulin-Dpf 47 kd log age-insulin-no heartrate-*2 BMI 51 kd log age-insulin-no heartrate-*2 BMI 51 kd log age-insulin-no heartrate-*2 Insulin 23 kd log age-insulin-no heartrate-*3 BMI 25 kd log age-insulin-no heartrate-*3 BMI 25 kd log age-insulin-no blabetesPedigreeFunction 38 kd log age-insulin-no DiabetesPedigreeFunction 48 kd log age-insulin-no Biodice-pesilon:1e-06 6 kd whole model-epsilon:1e-07 14 kd whole model-epsilon:1e-06 6 kd whole model-epsilon:1e-07 17 kd whole model-epsilon:1e-08 15 kd log age-insulin-no BloodPressure 31 kd log age-insulin-no BloodPressure 35 kd log age-insulin-no SkinThickness 36 kd	50	kd	log age-insulin-no heartrate-*3 Glucose
41 kd log age-insulin 27 kd log age-insulin 30 kd log age-insulin-no log age-insulin-no log age-insulin-no log age-insulin-no heartrate*2 28 kd log age-insulin-no heartrate*2 BMI 47 kd log age-insulin-no heartrate*2 EMI 51 kd log age-insulin-no heartrate*2 Insulin 66 kd log DiabetesPedigreeFunction 38 kd log age-insulin-no DiabetesPedigreeFunction 16 kd whole model-epsilon:le-08 14 kd whole model-epsilon:le-08 14 kd whole model-epsilon:le-08 14 kd whole model-epsilon:le-08 14 kd whole model-epsilon:le-08 15 kd log age-insulin-no DiabetesPedigreeFunction 16 kd whole model-epsilon:le-08 14 kd whole model-epsilon:le-08 14 kd log age-insulin-no BloodPressure 15 kd log age-insulin-no SkinThickness 16 kd log age-insulin-no BloodPressure 18 kd log age-insulin-no Blo	42	kd	<pre>log age-insulin-no heartrate-*2 Glucose</pre>
27 kd log age-insulin 30 kd log age-insulin 30 kd log age-insulin 28 kd log age-insulin-ppf 47 kd log age-insulin-no heartrate-*2 BMI 51 kd log age-insulin-no heartrate-*3 BloodPressure 46 kd log age-insulin-no heartrate-*2 Insulin 23 kd log age-insulin-no heartrate-*2 Insulin 55 kd log age-insulin-no heartrate-*3 BMI 55 kd log age-insulin-no biabetesPedigreeFunction 38 kd log age-insulin-no DiabetesPedigreeFunction 38 kd log age-insulin-no DiabetesPedigreeFunction 40 kd whole model-epsilon:1e-08 41 kd whole model-epsilon:1e-08 42 kd whole model-psilon:1e-09 43 kd log age-insulin-no BloodPressure 44 kd log age-insulin-no Pregnancies 45 kd log age-insulin-no Pregnancies 46 kd whole model-lr:lr_type.iteration 47 kd log age-insulin-no Pregnancies 48 kd log age-insulin-no Pregnancies 49 kd whole model-lr:lr_type.sample_size 40 kd whole model-lr:lr_type.sample_size 41 kd whole model-epsilon:1e-05 42 kd whole model-lr:lr_type.sample_size 43 kd log age-insulin-no heartrate-*3 Heart Rate 44 kd log age-insulin-no heartrate-*3 Heart Rate 49 kd log age-insulin-no heartrate-*3 Insulin 40 kd whole model-epsilon:0.0001 41 kd log age-insulin-no heartrate-*3 Insulin 42 kd log age-insulin-no heartrate-*3 Insulin 43 kd log age-insulin-no heartrate-*3 Insulin 44 kd log age-insulin-no heartrate-*3 Insulin 45 kd whole model-epsilon:0.001 46 kd log age-insulin-no heartrate-*2 Insulin-no BMI 47 kd log age-insulin-no heartrate-*2 Insulin-no BMI 48 kd log age-insulin-no heartrate-*2 Insulin-no BMI 48 kd log age-insulin-no heartrate-*2 Insulin-no BMI 48 kd log age-insulin-no heartrate-*2 Insulin-no BMI 49 kd log age-insulin-no heartrate-*2 Insulin-no BMI 40 kd log age-insulin-no heartrate-*2 Insulin-no BMI 41 kd log age-insulin-no heartrate-*2 Insulin-no BMI 42 kd log age-insulin-no heartrate-*2 Insulin-no BMI 44 kd log age-insulin-no heartrate-*2 Insulin-no BMI 45 kd log age-insulin-no heartrate-*2 Insulin-no BMI 46 kd log age-insulin-no heartrate-*2 Insulin-no BMI	43	kd	log age-insulin-no heartrate-*2 BloodPressure
27kdlog age-insulin30kdlog age-insulin-log age-insulin-Dpf28kdlog age-insulin-no heartrate-*2 BMI47kdlog age-insulin-no heartrate-*2 BMI51kdlog age-insulin-no heartrate-*3 BloodPressure46kdlog age-insulin-no heartrate-*2 Insulin23kdlog DiabetesPedigreeFunction55kdlog DiabetesPedigreeFunction38kdlog age-insulin-no DiabetesPedigreeFunction44kdwhole model-epsilon:1e-0845kdwhole model-epsilon:1e-0946kdwhole model-epsilon:1e-0646kdwhole model-epsilon:1e-0747kdwhole model-epsilon:1e-0748dlog age-insulin-no BloodPressure33kdlog age-insulin-no Pregnancies34kdlog age-insulin-no Pregnancies35kdlog age-insulin-no heartrate-*2 Heart Rate44kdlog age-insulin-no heartrate-*2 Heart Rate44kdlog age-insulin-no heartrate-*3 Heart Rate45kdwhole model-epsilon:1e-057kdwhole model-epsilon:0.000124kdlog age-insulin-no heartrate-*3 Insulin25kdlog age-insulin-no heartrate-*3 Insulin26kdlog age-insulin-no heartrate-*3 Insulin27kdlog age-insulin-no heartrate-*3 Insulin28kdlog age-insulin-no beat-epsilon:0.00124kdlog Bod-insulin-no beat-epsilon:0.001 <td>41</td> <td>kd</td> <td>log age-insulin-no heartrate-*2 Pregnancies</td>	41	kd	log age-insulin-no heartrate-*2 Pregnancies
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2
           kd
                                               whole model-lr:0.25
                                                whole model-lr:0.5
1
           kd
3
           kd
                                              whole model-lr:0.125
9
           kd
                       whole model-lr:lr type.hundred sample size
                  learning_rate iteration \
53
     lr_type.iteration_plus_one
                                       877
     lr type.iteration plus one
49
                                       858
40
     lr_type.iteration_plus_one
                                       813
34
     lr_type.iteration_plus_one
                                       813
     lr_type.iteration_plus_one
                                       708
50
     lr_type.iteration_plus_one
42
                                       706
43
     lr_type.iteration_plus_one
                                       702
41
     lr_type.iteration_plus_one
                                       832
27
     lr_type.iteration_plus_one
                                       836
30
     lr_type.iteration_plus_one
                                       836
     lr type.iteration plus one
28
                                       742
47
     lr_type.iteration_plus_one
                                       938
     lr type.iteration plus one
51
                                       695
46
     lr_type.iteration_plus_one
                                       741
23
     lr_type.iteration_plus_one
                                       802
     lr_type.iteration_plus_one
                                       959
55
25
     lr_type.iteration_plus_one
                                       1118
     lr_type.iteration_plus_one
38
                                       995
16
     lr_type.iteration_plus_one
                                       9021
14
     lr_type.iteration_plus_one
                                       1476
6
     lr_type.iteration_plus_one
                                       1476
     lr_type.iteration_plus_one
26
                                       1425
15
     lr_type.iteration_plus_one
                                       3643
17
     lr_type.iteration_plus_one
                                      22164
33
     lr_type.iteration_plus_one
                                       656
31
     lr_type.iteration_plus_one
                                       877
35
     lr_type.iteration_plus_one
                                       987
5
                                       2220
              lr type.iteration
44
     lr_type.iteration_plus_one
                                       834
18
     lr_type.iteration_plus_one
                                       1129
0
                            0.01
                                       956
13
     lr_type.iteration_plus_one
                                       636
7
            lr_type.sample_size
                                       2048
52
     lr_type.iteration_plus_one
                                       893
     lr_type.iteration_plus_one
19
                                       560
12
     lr_type.iteration_plus_one
                                       314
```

```
lr_type.iteration_plus_one
                                       750
54
22
     lr_type.iteration_plus_one
                                       1075
37
     lr_type.iteration_plus_one
                                       711
     lr_type.iteration_plus_one
21
                                       1008
29
     lr_type.iteration_plus_one
                                       978
11
     lr_type.iteration_plus_one
                                        165
48
     lr_type.iteration_plus_one
                                       1274
20
     lr type.iteration plus one
                                       1045
8
        lr_type.ten_sample_size
                                       3516
39
     lr type.iteration plus one
                                       790
36
     lr_type.iteration_plus_one
                                       1293
56
     lr type.iteration plus one
                                       1714
10
     lr_type.iteration_plus_one
                                         84
                                       1507
45
     lr_type.iteration_plus_one
32
     lr_type.iteration_plus_one
                                       484
4
                            0.05
                                    150000
2
                            0.25
                                    150000
1
                             0.5
                                    150000
3
                                     150000
                           0.125
9
    lr_type.hundred_sample_size
                                          2
                                                weights
                                                               epsilon \
    [[2.7512737233256144], [8.386789991625008], [-...
                                                       1.000000e-06
53
49
    [[3.733327173884576], [8.180972680577565], [-1...
                                                       1.000000e-06
40
    [[2.7129340471248065], [8.273684993858577], [-...
                                                       1.000000e-06
    [[2.7129340471248065], [8.273684993858577], [-...
34
                                                       1.000000e-06
    [[2.8106015374663595], [5.369363601783941], [-...
50
                                                       1.000000e-06
42
    [[2.7707684939995394], [5.782931625664704], [-...
                                                       1.000000e-06
    [[2.6840445568619615], [8.100362853592744], [-...
43
                                                       1.000000e-06
41
    [[3.7667195356425127], [8.238912283417783], [-...
                                                       1.000000e-06
    [[2.7683606646024232], [8.122909449757739], [-...
27
                                                       1.000000e-06
    [[2.7683606646024232], [8.122909449757739], [-...
30
                                                       1.000000e-06
28
    [[2.81722351586145], [8.11597903143088], [-0.8...
                                                       1.000000e-06
47
    [[3.1911630539778977], [8.668229576381282], [-...
                                                       1.000000e-06
51
    [[2.6832157340323204], [8.090166152115357], [-...
                                                       1.000000e-06
    [[2.5822636064767592], [7.952642108792551], [-...
46
                                                       1.000000e-06
    [[2.686500388124719], [8.005602930239544], [-0...
23
                                                       1.000000e-06
    [[3.3886056455906357], [8.833035181633305], [-...
55
                                                       1.000000e-06
    [[3.1317646256736045], [8.935591338567065], [-...
25
                                                       1.000000e-06
    [[3.528294663986213], [8.888662016489207], [-0...
38
                                                       1.000000e-06
16
    [[2.96533714092659], [8.33217514426845], [-1.0...
                                                       1.000000e-08
14
    [[3.175241989157885], [9.517996847051375], [-1...
                                                       1.000000e-06
6
    [[3.175241989157885], [9.517996847051375], [-1...
                                                       1.000000e-06
```

1341

24

26

15

17

lr_type.iteration_plus_one

1.000000e-06

1.000000e-07

1.000000e-09

[[3.2317379647520714], [9.47235968785085], [-1...

[[3.0601381991207917], [8.83862515342757], [-1...

[[2.887385852612343], [7.9553323804450375], [-...

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[[7.954655592251466], [-1.0448422866347953], [...
31
                                                        1.000000e-06
35
    [[2.8454163866127455], [7.444158178181417], [-...
                                                        1.000000e-06
5
    [[3.6602142620593963], [11.56162794637247], [-...
                                                        1.000000e-06
    [[2.724842549802258], [8.017986056469372], [-1...
44
                                                        1.000000e-06
18
    [[0.47048312539781034], [8.606990965621858], [...
                                                        1.000000e-06
0
    [[2.5819277747484066], [6.780007402086465], [-...
                                                        1.000000e-06
13
    [[3.3327577160627104], [10.39377495841507], [-...
                                                        1.000000e-05
    [[2.5011580589018196], [6.514304926750582], [-...
7
                                                        1.000000e-06
    [[2.7265668621754484], [7.7797756044220066], [...
52
                                                        1.000000e-06
    [[2.7341191226158608], [1.1070301791999142], [...
19
                                                        1.000000e-06
    [[3.6109084400585387], [11.42702526345321], [-...
                                                        1.000000e-04
12
24
    [[3.016669053499772], [9.333632805388874], [-1...
                                                        1.000000e-06
54
    [[2.4931005393729446], [7.908737551062805], [-...
                                                        1.000000e-06
22
    [[3.097120568287582], [8.175406022439612], [-1...
                                                        1.000000e-06
37
    [[2.5109910019024677], [7.816325231383992], [-...
                                                        1.000000e-06
    [[2.7030305464057154], [8.683157932519787], [-...
21
                                                        1.000000e-06
    [[2.989559318463753], [8.044352212204572], [-1...
29
                                                        1.000000e-06
    [[4.254111597053624], [12.705390512862264], [-...
                                                        1.000000e-03
11
    [[2.8730033537390356], [8.894450845054584], [-...
48
                                                        1.000000e-06
    [[3.0167390363517588], [8.607754261039704], [0...
20
                                                        1.000000e-06
    [[1.8917011563673924], [3.7425174840678586], [...
8
                                                        1.000000e-06
    [[2.5616285768893263], [7.794299182419026], [-...
39
                                                        1.000000e-06
    [[2.820836202474606], [9.936728220495777], [-0...
36
                                                        1.000000e-06
    [[2.8470517371490716], [9.636035150531411], [-...
56
                                                        1.000000e-06
10
    [[5.958742925531525], [14.327917968306403], [-...
                                                        1.000000e-02
45
    [[2.8269443408264547], [10.095837895438326], [...
                                                        1.000000e-06
    [[2.360917183337187], [-0.8182987407890269], [...
32
                                                        1.000000e-06
4
    [[9.970728371948313], [26.491694165903258], [-...
                                                        1.000000e-06
    [[47.64433276868854], [130.6790054571249], [-1...
2
                                                        1.000000e-06
    [[95.81933692733199], [262.7825656994754], [-3...
1
                                                        1.000000e-06
    [[24.070810464619214], [65.46666343519061], [-...
3
                                                        1.000000e-06
9
    [[0.0003065942121212121], [0.00038259484848484...
                                                        1.000000e-06
    elapsed_time is_max_reached
                                         loss
                                               accuracy_kfold
                                                                        variable
53
           0.058
                           False
                                    15.777801
                                                      0.773737
                                                                      feature *3
49
           0.043
                           False
                                    16.092013
                                                      0.761279
                                                                      feature *3
40
           0.045
                           False
                                    15.717127
                                                      0.759933
                                                                feature removal
34
                           False
                                    15.717127
                                                                feature removal
           0.062
                                                      0.759933
50
           0.035
                           False
                                    15.784424
                                                      0.758923
                                                                      feature *3
42
           0.032
                           False
                                    15.705729
                                                      0.758586
                                                                      feature *2
43
           0.033
                           False
                                    15.651793
                                                      0.758249
                                                                      feature *2
41
           0.046
                           False
                                    15.915845
                                                                      feature *2
                                                      0.758249
27
           0.035
                           False
                                    15.737679
                                                      0.757576
                                                                             log
30
           0.049
                           False
                                    15.737679
                                                      0.757576
                                                                             log
28
           0.036
                           False
                                    15.629731
                                                      0.756902
                                                                             log
47
           0.039
                           False
                                    15.849282
                                                      0.756566
                                                                      feature *2
```

[[2.726699034298592], [7.741999408211606], [-0...

1.000000e-06

33

51	0.039	False	15.634238	0.756229	feature *3
46	0.031	False	15.840965	0.755556	feature *2
23	0.037	False	15.821280	0.755556	log
55	0.045	False	15.814899	0.755219	feature *3
25	0.051	False	16.145685	0.751852	log
38	0.072	False	15.632706	0.751852	feature removal
16	0.413	False	16.097559	0.751515	epsilon
14	0.072	False	16.436353	0.751515	epsilon
6	0.105	False	16.436353	0.751515	learning rate
26	0.070	False	16.404716	0.751515	log
15	0.166	False	16.225842	0.751178	epsilon
17	0.940	False	16.019264	0.750842	epsilon
33	0.046	False	15.583091	0.750842	feature removal
31	0.041	False	16.310581	0.750842	feature removal
35	0.073	False	15.788618	0.750505	feature removal
5	0.162	False	17.234261	0.750505	learning rate
44	0.102	False	15.823767	0.750168	feature *2
18	0.038	False	16.526437	0.750168	
0	0.048	False	15.855793	0.749495	log all features
13	0.049	False	16.775910	0.749495	
7	0.155	False	15.849570	0.749495	epsilon
7 52		False	15.929618		learning rate feature *3
52 19	0.044			0.748822	
19 12	0.023	False	16.070200	0.748485	log
	0.013	False	17.369442	0.747475	epsilon
24	0.056	False	16.234284	0.747138	log
54	0.036	False	15.882348	0.746801	feature *3
22	0.069	False	16.334522	0.746465	log
37	0.049	False	15.701077	0.746465	feature removal
21	0.044	False	16.245876	0.744781	log
29	0.061	False	16.176293	0.744108	log
11	0.009	False	18.607920	0.743771	epsilon
48	0.055	False	16.098061	0.743771	feature *2
20	0.052	False	16.291746	0.743434	log
8	0.266	False	16.462365	0.741414	learning rate
39	0.061	False	15.972236	0.740067	feature removal
36	0.099	False	17.179665	0.739731	feature removal
56	0.081	False	16.352570	0.739394	feature *3
10	0.009	False	21.366778	0.737037	epsilon
45	0.066	False	17.222705	0.735690	feature *2
32	0.035	False	17.264986	0.729630	feature removal
4	6.472	True	46.838322	0.688552	learning rate
2	6.500	True	106.221172	0.683502	learning rate
1	8.592	True	118.189617	0.683165	learning rate
3	8.383	True	87.970034	0.683165	learning rate
9	0.000	False	20.585959	0.516835	learning rate

```
[47]: #(model data['variable'] == 'learning rate')
      model_data.loc[model_data['variable'] == 'feature removal']
      #model_data.loc[model_data['variable'] == 'all features']
      #.sort_values(by=['accuracy_kfold'], ascending=False))
[47]:
         model_name
                                                      description \
      31
                 kd
                                  log age-insulin-no Pregnancies
      32
                                       log age-insulin-no Glucose
                 kd
      33
                 kd
                                log age-insulin-no BloodPressure
      34
                 kd
                                    log age-insulin-no Heart Rate
      35
                 kd
                                log age-insulin-no SkinThickness
      36
                 kd
                                       log age-insulin-no Insulin
      37
                 kd
                                           log age-insulin-no BMI
      38
                 kd
                     log age-insulin-no DiabetesPedigreeFunction
                                           log age-insulin-no Age
      39
                 kd
      40
                 kd
                                     log age-insulin-no heartrate
                       learning_rate iteration
          lr_type.iteration_plus_one
                                            877
      31
      32
         lr_type.iteration_plus_one
                                            484
      33
         lr_type.iteration_plus_one
                                            656
      34
         lr_type.iteration_plus_one
                                            813
      35
         lr_type.iteration_plus_one
                                            987
         lr_type.iteration_plus_one
                                           1293
      36
          lr type.iteration plus one
      37
                                            711
         lr type.iteration plus one
                                            995
      38
         lr_type.iteration_plus_one
                                            790
         lr type.iteration plus one
                                            813
                                                                         elapsed_time \
                                                     weights
                                                               epsilon
          [[7.954655592251466], [-1.0448422866347953], [...
      31
                                                            0.000001
                                                                              0.041
      32
          [[2.360917183337187], [-0.8182987407890269], [...
                                                            0.000001
                                                                              0.035
          [[2.726699034298592], [7.741999408211606], [-0...
                                                            0.00001
                                                                              0.046
      33
          [[2.7129340471248065], [8.273684993858577], [-...
      34
                                                            0.00001
                                                                              0.062
          [[2.8454163866127455], [7.444158178181417], [-...
      35
                                                            0.00001
                                                                              0.073
          [[2.820836202474606], [9.936728220495777], [-0...
                                                            0.00001
                                                                              0.099
          [[2.5109910019024677], [7.816325231383992], [-...
                                                            0.00001
                                                                              0.049
      37
          [[3.528294663986213], [8.888662016489207], [-0...
                                                                              0.072
      38
                                                            0.00001
          [[2.5616285768893263], [7.794299182419026], [-...
                                                                              0.061
      39
                                                            0.000001
          [[2.7129340471248065], [8.273684993858577], [-...
      40
                                                            0.000001
                                                                              0.045
         is_max_reached
                              loss accuracy_kfold
                                                            variable
      31
                  False
                        16.310581
                                           0.750842 feature removal
      32
                  False 17.264986
                                           0.729630 feature removal
      33
                  False 15.583091
                                           0.750842 feature removal
      34
                  False 15.717127
                                           0.759933 feature removal
```

35	False	15.788618	0.750505	feature removal
36	False	17.179665	0.739731	feature removal
37	False	15.701077	0.746465	feature removal
38	False	15.632706	0.751852	feature removal
39	False	15.972236	0.740067	feature removal
40	False	15.717127	0.759933	feature removal

whitewhine_model

February 19, 2023

```
[66]: #delete_model(model_data)
     show_sorted_model(model_data)
      #print(kd_x_train.shape)
      #delete_model(model_data)
[66]: Empty DataFrame
     Columns: [model_name, description, learning_rate, iteration, weights, epsilon,
     elapsed_time, is_max_reached, loss, accuracy_kfold, variable]
     Index: []
[67]: model_data = run_model('ww', 'whole model', learning_rate = 0, learning_rate_type_
       →= learning_rate_type.iteration ,max_iterations = 150000,
                            epsilon = 1e-5,x_train = ww_x_train , y_train =_
      →ww_y_train , model_data = model_data, variable = 'all features')
     show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[67]: model_name description
                                    learning_rate iteration \
                  whole model lr_type.iteration
                                                       4032
                                                  weights epsilon elapsed_time \
     0 [[16.378906342486571375], [-5.5259574517590583... 0.00001
                                                                         5.061
       is_max_reached
                            loss accuracy_kfold
                                                      variable
                False 97.099984
                                        0.735186 all features
```

i====> 1 i====> 2 i====> 3 i====> 4 i====> 5 i====> 6 i====> 7 i====> 8 i====> 9 i====> 0 i====> 1 i====> 2 i====> 3 i====> 4 i====> 5 i====> 6 i====> 7 i====> 8 i====> 9 i====> 0 i====> 1

i====> 2

i====> 0

```
i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i =====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[69]:
                                                 description \
       model_name
     2
                    whole model-lr:lr_type.iteration_plus_one
               WW
     0
                                                 whole model
               WW
     1
                             whole model-lr:lr_type.iteration
               WW
     3
                           whole model-lr:lr_type.sample_size
               WW
                       whole model-lr:lr_type.ten_sample_size
     4
               ww
                   whole model-lr:lr_type.hundred_sample_size
                      learning_rate iteration \
     2
         lr_type.iteration_plus_one
                                         2753
     0
                                         4032
                  lr_type.iteration
     1
                  lr_type.iteration
                                         4032
     3
                lr_type.sample_size
                                         1362
            lr_type.ten_sample_size
                                           74
        lr_type.hundred_sample_size
                                            2
                                                 weights epsilon elapsed_time \
       [[12.1374092489669549964], [-4.520518798900213... 0.00001
                                                                        1.110
     0 [[16.378906342486571375], [-5.5259574517590583... 0.00001
                                                                        5.061
```

```
1 [[16.378906342486571375], [-5.5259574517590583... 0.00001
                                                                        1.660
     3 [[3.239870586975073716], [-3.93183866315446415... 0.00001
                                                                        0.605
     4 [[0.07851626733184168337], [-0.114624863637962... 0.00001
                                                                        0.044
     5 [[0.00018731212820512820378], [-9.962399624765... 0.00001
                                                                        0.001
       is_max_reached
                            loss accuracy_kfold
                                                       variable
     2
                False
                       86.235038
                                        0.738105 learning rate
     0
                False 97.099984
                                        0.735186
                                                 all features
     1
                False 97.099984
                                        0.735186 learning rate
     3
                False 80.126535
                                        0.729210 learning rate
     4
                False 98.565776
                                        0.536584 learning rate
                False 99.809458
                                        0.535056 learning rate
[70]: #explore different epsilons
     epsilon list = [1e-2, 1e-3, 1e-4, 1e-5, 1e-6, 1e-7, 1e-8, 1e-9]
     for i in range(len(epsilon_list)):
       title = 'whole model-epsilon:' + str(epsilon_list[i])
       model_data = run_model('ww',title,learning_rate = 0, learning_rate_type =_u
       Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                            epsilon = epsilon_list[i],x_train = ww_x_train , y_train_
       ⇔= ww_y_train , model_data = model_data, variable = 'epsilon')
     show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     i====> 0
     i====> 1
     i====> 2
     i====> 3
```

- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9 i====> 0
- i====> 1
- i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1 i====> 2
- i====> 3
- i====> 4
- i====> 5
- i====> 6
- i====> 7
- i====> 8
- i====> 9
- i====> 0
- i====> 1

```
i====> 2
     i====>
     i====>
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[70]:
         model_name
                                                      description \
                                       whole model-epsilon:1e-07
      11
                 WW
      12
                 ww
                                       whole model-epsilon:1e-08
      2
                       whole model-lr:lr_type.iteration_plus_one
                 WW
                 ww
      9
                                       whole model-epsilon:1e-05
      13
                                       whole model-epsilon:1e-09
                 ww
      10
                                       whole model-epsilon:1e-06
                 WW
      0
                                                      whole model
      1
                                whole model-lr:lr_type.iteration
      8
                                      whole model-epsilon:0.0001
                 WW
      6
                 WW
                                        whole model-epsilon:0.01
      3
                              whole model-lr:lr_type.sample_size
                 WW
      7
                                       whole model-epsilon:0.001
                 WW
      4
                          whole model-lr:lr_type.ten_sample_size
                 ww
      5
                     whole model-lr:lr_type.hundred_sample_size
                        learning_rate iteration
      11
           lr_type.iteration_plus_one
                                           10464
      12
           lr type.iteration plus one
                                           19610
      2
           lr_type.iteration_plus_one
                                            2753
      9
           lr type.iteration plus one
                                            2753
      13
           lr_type.iteration_plus_one
                                           36990
      10
                                            5496
           lr_type.iteration_plus_one
      0
                    lr_type.iteration
                                            4032
      1
                    lr_type.iteration
                                            4032
      8
           lr_type.iteration_plus_one
                                            1263
      6
           lr_type.iteration_plus_one
                                             235
      3
                  lr_type.sample_size
                                            1362
      7
           lr_type.iteration_plus_one
                                             531
      4
                                              74
              lr_type.ten_sample_size
      5
          lr_type.hundred_sample_size
                                               2
                                                      weights
                                                                    epsilon \
      11
          [[9.087798687760632232], [-4.04964890730847365...
                                                             1.000000e-07
          [[8.305635754643900189], [-4.08145059850403449... 1.000000e-08
      12
      2
          [[12.1374092489669549964], [-4.520518798900213...
                                                             1.000000e-05
          [[12.1374092489669549964], [-4.520518798900213...
      9
                                                             1.000000e-05
          [[7.7814651988257482708], [-4.1149838488482304...
                                                             1.000000e-09
      13
```

```
10
          [[10.283574906574218732], [-4.1060086401810997...
                                                               1.000000e-06
      0
          [[16.378906342486571375], [-5.5259574517590583...
                                                               1.000000e-05
      1
          [[16.378906342486571375], [-5.5259574517590583...
                                                               1.000000e-05
      8
           [[14.944116734687297383], [-5.9888301416859652...
                                                               1.000000e-04
      6
           [[20.268681216307229112], [-17.891141982398493...
                                                               1.000000e-02
      3
          [[3.239870586975073716], [-3.93183866315446415...
                                                               1.000000e-05
      7
          [[18.400300481674902137], [-9.9749477354584466...
                                                               1.000000e-03
      4
           \hbox{\tt [[0.07851626733184168337], [-0.114624863637962...]}
                                                               1.000000e-05
          [[0.00018731212820512820378], [-9.962399624765...
      5
                                                               1.000000e-05
          elapsed_time is_max_reached
                                                loss
                                                      accuracy_kfold
                                                                             variable
      11
                  4.588
                                  False
                                           80.926339
                                                             0.739631
                                                                              epsilon
      12
                  7.677
                                  False
                                           80.216146
                                                             0.739354
                                                                              epsilon
      2
                  1.110
                                  False
                                           86.235038
                                                             0.738105
                                                                        learning rate
      9
                  1.104
                                  False
                                           86.235038
                                                                              epsilon
                                                             0.738105
      13
                 15.933
                                  False
                                           79.885937
                                                             0.738036
                                                                              epsilon
      10
                                  False
                  2.197
                                           82.538558
                                                             0.737964
                                                                              epsilon
      0
                  5.061
                                  False
                                           97.099984
                                                             0.735186
                                                                         all features
      1
                  1.660
                                  False
                                           97.099984
                                                             0.735186
                                                                        learning rate
      8
                  0.522
                                  False
                                           94.274794
                                                             0.734561
                                                                              epsilon
                                                                              epsilon
      6
                  0.151
                                  False
                                         134.658479
                                                             0.729835
      3
                  0.605
                                  False
                                          80.126535
                                                             0.729210
                                                                        learning rate
      7
                  0.365
                                        109.385158
                                  False
                                                             0.728721
                                                                              epsilon
      4
                                                             0.536584
                  0.044
                                  False
                                          98.565776
                                                                        learning rate
      5
                  0.001
                                  False
                                           99.809458
                                                                        learning rate
                                                             0.535056
      ww_x_train_np = pd.DataFrame(ww_x_train)
[71]:
[72]:
      show_sorted_model(model_data)
[72]:
                                                        description \
         model_name
      11
                                        whole model-epsilon:1e-07
                  WW
      12
                                        whole model-epsilon:1e-08
                  WW
      2
                  WW
                       whole model-lr:lr_type.iteration_plus_one
      9
                                        whole model-epsilon:1e-05
                  WW
      13
                                        whole model-epsilon:1e-09
                  WW
      10
                                        whole model-epsilon:1e-06
                  ww
      0
                                                        whole model
                  ww
      1
                                 whole model-lr:lr_type.iteration
                  WW
      8
                                       whole model-epsilon:0.0001
                  ww
      6
                                         whole model-epsilon:0.01
                  ww
      3
                  ww
                               whole model-lr:lr_type.sample_size
      7
                                         whole model-epsilon:0.001
                  ww
      4
                          whole model-lr:lr_type.ten_sample_size
                  ww
      5
                      whole model-lr:lr_type.hundred_sample_size
```

learning_rate iteration

```
11
     lr_type.iteration_plus_one
                                      10464
12
     lr_type.iteration_plus_one
                                      19610
2
     lr_type.iteration_plus_one
                                       2753
9
     lr_type.iteration_plus_one
                                       2753
13
     lr_type.iteration_plus_one
                                      36990
10
     lr_type.iteration_plus_one
                                       5496
0
              lr_type.iteration
                                       4032
1
              lr_type.iteration
                                       4032
8
     lr type.iteration plus one
                                       1263
6
     lr_type.iteration_plus_one
                                        235
3
            lr type.sample size
                                       1362
7
     lr_type.iteration_plus_one
                                        531
4
        lr type.ten sample size
                                         74
                                          2
5
    lr_type.hundred_sample_size
                                                weights
                                                               epsilon \
    [[9.087798687760632232], [-4.04964890730847365...
                                                        1.000000e-07
11
12
    [[8.305635754643900189], [-4.08145059850403449...
                                                        1.000000e-08
    [[12.1374092489669549964], [-4.520518798900213...
2
                                                        1.000000e-05
9
    [[12.1374092489669549964], [-4.520518798900213...
                                                        1.000000e-05
    [[7.7814651988257482708], [-4.1149838488482304...
13
                                                        1.000000e-09
10
    [[10.283574906574218732], [-4.1060086401810997...
                                                        1.000000e-06
0
    [[16.378906342486571375], [-5.5259574517590583...
                                                        1.000000e-05
1
    [[16.378906342486571375], [-5.5259574517590583...
                                                        1.000000e-05
8
    [[14.944116734687297383], [-5.9888301416859652...
                                                        1.000000e-04
6
    [[20.268681216307229112], [-17.891141982398493...
                                                        1.000000e-02
3
    [[3.239870586975073716], [-3.93183866315446415...
                                                        1.000000e-05
7
    [[18.400300481674902137], [-9.9749477354584466...
                                                        1.000000e-03
4
    [[0.07851626733184168337], [-0.114624863637962...
                                                        1.000000e-05
5
    [[0.00018731212820512820378], [-9.962399624765...
                                                        1.000000e-05
    elapsed_time is_max_reached
                                               accuracy_kfold
                                                                     variable
                                         loss
           4.588
                           False
                                   80.926339
11
                                                      0.739631
                                                                       epsilon
12
           7.677
                           False
                                   80.216146
                                                      0.739354
                                                                       epsilon
2
           1.110
                           False
                                   86.235038
                                                                learning rate
                                                      0.738105
9
           1.104
                           False
                                   86.235038
                                                      0.738105
                                                                       epsilon
13
          15.933
                           False
                                   79.885937
                                                                       epsilon
                                                      0.738036
10
           2.197
                           False
                                   82.538558
                                                                       epsilon
                                                      0.737964
0
           5.061
                           False
                                   97.099984
                                                      0.735186
                                                                 all features
1
           1.660
                           False
                                   97.099984
                                                                learning rate
                                                      0.735186
8
                           False
           0.522
                                   94.274794
                                                      0.734561
                                                                       epsilon
6
           0.151
                           False
                                  134.658479
                                                      0.729835
                                                                       epsilon
3
           0.605
                           False
                                   80.126535
                                                      0.729210
                                                                learning rate
7
           0.365
                           False
                                  109.385158
                                                      0.728721
                                                                       epsilon
4
           0.044
                           False
                                   98.565776
                                                      0.536584
                                                                learning rate
5
                                   99.809458
           0.001
                           False
                                                      0.535056
                                                                learning rate
```

```
[73]: #explore different logs of features
     for i in range(ww_x_train.shape[1]):
         print (i,',log , column=>',ww_columns[i])
         ww_x_train_modified = log_transform_normalize(ww_x_train_np,i)
         title = 'log {}'.format(ww_columns[i])
         model_data = run_model('ww',title,learning_rate = 0, learning_rate_type =_
       Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                            epsilon = 1e-5,x_train = ww_x_train_modified , y_train =_
      →ww_y_train , model_data = model_data, variable = 'log')
     show_sorted_model(model_data)
     0 ,log , column=> Alcohol
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     1 ,log , column=> Malic acid
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     2 ,log , column=> Ash
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     3 ,log , column=> Alkalinity of ash
     i====> 0
```

i====> 1

```
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,log , column=> Magnesium
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,log , column=> Total phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,log , column=> Flavanoids
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
7 ,log , column=> Nonflavanoid phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
```

```
i====> 7
     i====> 8
     i====> 9
     8 ,log , column=> Proanthocyanins
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     9 ,log , column=> Hue
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[73]:
                                                   description \
        model_name
      19
                                              log Total phenols
     11
                                     whole model-epsilon:1e-07
                WW
     12
                                     whole model-epsilon:1e-08
                WW
     22
                                            log Proanthocyanins
                WW
                                     whole model-epsilon:1e-05
     9
                WW
     2
                      whole model-lr:lr_type.iteration_plus_one
                ww
     13
                                     whole model-epsilon:1e-09
                WW
     10
                                     whole model-epsilon:1e-06
                WW
     23
                                                        log Hue
                WW
     18
                                                 log Magnesium
                w
     21
                                       log Nonflavanoid phenols
                              whole model-lr:lr_type.iteration
      1
      0
                                                    whole model
                ww
     15
                ww
                                                 log Malic acid
     8
                                    whole model-epsilon:0.0001
                ww
     16
                                                        log Ash
                ww
     20
                                                 log Flavanoids
                WW
                                          log Alkalinity of ash
     17
                ww
     6
                                      whole model-epsilon:0.01
                WW
```

i====> 6

```
3
                        whole model-lr:lr_type.sample_size
           WW
7
                                 whole model-epsilon:0.001
           WW
14
           ww
                                                log Alcohol
4
                    whole model-lr:lr_type.ten_sample_size
           ww
5
               whole model-lr:lr_type.hundred_sample_size
           ww
                  learning_rate iteration
19
     lr_type.iteration_plus_one
                                       2743
     lr type.iteration plus one
11
                                     10464
12
     lr_type.iteration_plus_one
                                     19610
22
     lr type.iteration plus one
                                       2439
9
     lr_type.iteration_plus_one
                                       2753
2
     lr type.iteration plus one
                                       2753
     lr_type.iteration_plus_one
13
                                     36990
     lr_type.iteration_plus_one
10
                                       5496
23
     lr_type.iteration_plus_one
                                       2118
     lr_type.iteration_plus_one
18
                                       2205
21
     lr_type.iteration_plus_one
                                       1844
1
              lr_type.iteration
                                       4032
              lr_type.iteration
0
                                       4032
15
     lr_type.iteration_plus_one
                                       2115
8
     lr type.iteration plus one
                                       1263
16
     lr_type.iteration_plus_one
                                       3062
20
     lr type.iteration plus one
                                       1934
17
     lr_type.iteration_plus_one
                                       2904
6
     lr_type.iteration_plus_one
                                       235
3
            lr_type.sample_size
                                       1362
7
     lr_type.iteration_plus_one
                                       531
     lr_type.iteration_plus_one
14
                                       2469
4
        lr_type.ten_sample_size
                                         74
5
    lr_type.hundred_sample_size
                                          2
                                                weights
                                                               epsilon \
    [[11.472057505397014435], [-4.4349784278962545...
19
                                                       1.000000e-05
11
    [[9.087798687760632232], [-4.04964890730847365...
                                                        1.000000e-07
12
    [[8.305635754643900189], [-4.08145059850403449...
                                                       1.000000e-08
22
    [[12.136361209371475922], [-4.3072039982668131...
                                                       1.000000e-05
9
    [[12.1374092489669549964], [-4.520518798900213...
                                                       1.000000e-05
2
    [[12.1374092489669549964], [-4.520518798900213...
                                                       1.000000e-05
    [[7.7814651988257482708], [-4.1149838488482304...
                                                       1.000000e-09
13
    [[10.283574906574218732], [-4.1060086401810997...
10
                                                       1.000000e-06
23
    [[10.550083355026051274], [-4.1522402634849284...
                                                       1.000000e-05
    [[12.378667135942420577], [-5.2467260468350486...
18
                                                       1.000000e-05
21
    [[7.574352853182287649], [-4.53548774286644673...
                                                       1.000000e-05
    [[16.378906342486571375], [-5.5259574517590583...
                                                       1.000000e-05
1
    [[16.378906342486571375], [-5.5259574517590583...
0
                                                       1.000000e-05
    [[10.097329325595773509], [-0.4022719394966720...
15
                                                       1.000000e-05
```

```
[[14.944116734687297383], [-5.9888301416859652...
      8
                                                             1.000000e-04
          [[12.0433165615157943], [-3.423846932597623296...
      16
                                                             1.000000e-05
      20
          [[13.077075012640899667], [-5.3331788140696238...
                                                             1.000000e-05
          [[12.144219855790955124], [-5.0777700676349558...
      17
                                                             1.000000e-05
          [[20.268681216307229112], [-17.891141982398493...
                                                             1.000000e-02
      6
          [[3.239870586975073716], [-3.93183866315446415...
      3
                                                             1.000000e-05
      7
          [[18.400300481674902137], [-9.9749477354584466...
                                                             1.000000e-03
          [[1.2167490011416727461], [-3.4149019369519555...
      14
                                                             1.000000e-05
          [[0.07851626733184168337], [-0.114624863637962...
      4
                                                             1.000000e-05
      5
          [[0.00018731212820512820378], [-9.962399624765...
                                                             1.000000e-05
          elapsed_time is_max_reached
                                                     accuracy_kfold
                                                                           variable
                                               loss
      19
                 1.102
                                 False
                                         85.723087
                                                           0.742064
                                                                                log
      11
                 4.588
                                 False
                                         80.926339
                                                           0.739631
                                                                            epsilon
      12
                 7.677
                                                                            epsilon
                                 False
                                         80.216146
                                                           0.739354
      22
                 0.991
                                 False
                                         85.158078
                                                           0.738938
                                                                                log
      9
                 1.104
                                 False
                                         86.235038
                                                                            epsilon
                                                           0.738105
      2
                 1.110
                                 False
                                                                      learning rate
                                         86.235038
                                                           0.738105
      13
                15.933
                                 False
                                         79.885937
                                                           0.738036
                                                                            epsilon
      10
                 2.197
                                 False
                                         82.538558
                                                           0.737964
                                                                            epsilon
      23
                 0.867
                                 False
                                         81.190493
                                                           0.737131
                                                                                log
      18
                                 False
                                         83.420795
                 1.327
                                                           0.736923
                                                                                log
      21
                 1.140
                                 False
                                         82.468896
                                                           0.735949
                                                                                log
      1
                                 False
                 1.660
                                         97.099984
                                                           0.735186
                                                                      learning rate
      0
                 5.061
                                 False
                                         97.099984
                                                                       all features
                                                           0.735186
      15
                 0.878
                                 False
                                         83.854123
                                                           0.735117
                                                                                log
                                 False
                                         94.274794
                 0.522
                                                           0.734561
                                                                            epsilon
      16
                                 False
                                         87.890446
                 1.237
                                                           0.734283
                                                                                log
      20
                 0.812
                                 False
                                         85.514273
                                                           0.732755
                                                                                log
      17
                 1.434
                                 False
                                         85.180434
                                                           0.730737
                                                                                log
      6
                 0.151
                                 False
                                       134.658479
                                                           0.729835
                                                                            epsilon
      3
                 0.605
                                 False
                                         80.126535
                                                           0.729210
                                                                      learning rate
      7
                                 False
                 0.365
                                       109.385158
                                                           0.728721
                                                                            epsilon
      14
                 1.117
                                 False
                                         86.710362
                                                           0.725452
                                                                                log
      4
                 0.044
                                 False
                                         98.565776
                                                           0.536584
                                                                      learning rate
      5
                 0.001
                                 False
                                         99.809458
                                                           0.535056
                                                                      learning rate
[74]: #combine log Total phenols & Proanthocyanins
      ww x train logphenol = log transform normalize(ww x train np,5)
      ww_x_train_logpp = log_transform_normalize(ww_x_train_logphenol,8)
      model_data = run_model('ww','log Total phenols-Proanthocyanins',learning_rate =_
       →0, learning_rate_type = learning_rate_type.iteration_plus_one ,
                              max_iterations = 150000,epsilon = 1e-5,x_train =_
       \negww_x_train_logpp , y_train = ww_y_train , model_data = model_data,variable =

¬'log')
```

show_sorted_model(model_data)

```
i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[74]:
         model_name
                                                      description \
      19
                                               log Total phenols
                 ww
      24
                 ww
                               log Total phenols-Proanthocyanins
      11
                                       whole model-epsilon:1e-07
                 ww
      12
                                       whole model-epsilon:1e-08
                 ww
      22
                                             log Proanthocyanins
                 WW
      2
                       whole model-lr:lr_type.iteration_plus_one
                 WW
      9
                                       whole model-epsilon:1e-05
                 WW
      13
                 WW
                                       whole model-epsilon:1e-09
                                       whole model-epsilon:1e-06
      10
                 WW
      23
                                                          log Hue
                 WW
      18
                                                    log Magnesium
                 WW
      21
                                        log Nonflavanoid phenols
      1
                                whole model-lr:lr_type.iteration
      0
                                                      whole model
                 WW
      15
                                                   log Malic acid
                 ww
                                      whole model-epsilon:0.0001
                 WW
      16
                                                          log Ash
                 WW
      20
                                                   log Flavanoids
                 WW
                                           log Alkalinity of ash
      17
                 WW
      6
                                        whole model-epsilon:0.01
      3
                              whole model-lr:lr_type.sample_size
      7
                                       whole model-epsilon:0.001
                 ww
      14
                                                      log Alcohol
                 ww
                          whole model-lr:lr_type.ten_sample_size
      4
                 ww
      5
                     whole model-lr:lr_type.hundred_sample_size
                 ww
                        learning_rate iteration
      19
           lr_type.iteration_plus_one
                                            2743
      24
           lr type.iteration plus one
                                            2523
      11
           lr_type.iteration_plus_one
                                           10464
      12
           lr type.iteration plus one
                                           19610
      22
           lr_type.iteration_plus_one
                                            2439
      2
           lr_type.iteration_plus_one
                                            2753
      9
           lr_type.iteration_plus_one
                                            2753
      13
           lr_type.iteration_plus_one
                                           36990
```

```
lr_type.iteration_plus_one
23
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     lr_type.iteration_plus_one
18
                                       2205
21
     lr_type.iteration_plus_one
                                       1844
1
              lr_type.iteration
                                       4032
0
              lr_type.iteration
                                       4032
     lr_type.iteration_plus_one
15
                                       2115
8
     lr_type.iteration_plus_one
                                       1263
     lr type.iteration plus one
16
                                       3062
20
     lr_type.iteration_plus_one
                                       1934
17
     lr type.iteration plus one
                                       2904
6
     lr_type.iteration_plus_one
                                       235
3
            lr_type.sample_size
                                       1362
     lr_type.iteration_plus_one
7
                                       531
14
     lr_type.iteration_plus_one
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4
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                                         loss
                                               accuracy_kfold
                                                                     variable
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           1.102
                           False
                                   85.723087
                                                     0.742064
                                                                          log
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5496

10

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22 0.991 False 85.158078 0.738938 log 2 1.110 False 86.235038 0.738105 learning rate 9 1.104 False 86.235038 0.738105 epsilon 13 15.933 False 79.885937 0.738036 epsilon 10 2.197 False 82.538558 0.737964 epsilon 23 0.867 False 81.190493 0.737131 log 18 1.327 False 81.190493 0.736923 log 21 1.140 False 82.468896 0.735949 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 85.	11	4.588	False	80.926339	0.739631	epsilon
2 1.110 False 86.235038 0.738105 learning rate 9 1.104 False 86.235038 0.738105 epsilon 13 15.933 False 79.885937 0.738036 epsilon 10 2.197 False 82.538558 0.737964 epsilon 23 0.867 False 81.190493 0.737131 log 18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.	12	7.677	False	80.216146	0.739354	epsilon
9 1.104 False 86.235038 0.738105 epsilon 13 15.933 False 79.885937 0.738036 epsilon 10 2.197 False 82.538558 0.737964 epsilon 23 0.867 False 81.190493 0.737131 log 18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	22	0.991	False	85.158078	0.738938	log
13 15.933 False 79.885937 0.738036 epsilon 10 2.197 False 82.538558 0.737964 epsilon 23 0.867 False 81.190493 0.737131 log 18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 80.126535 0.729835 epsilon 3 0.605 False 80.126535 <td>2</td> <td>1.110</td> <td>False</td> <td>86.235038</td> <td>0.738105</td> <td>learning rate</td>	2	1.110	False	86.235038	0.738105	learning rate
10 2.197 False 82.538558 0.737964 epsilon 23 0.867 False 81.190493 0.737131 log 18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.3851	9	1.104	False	86.235038	0.738105	epsilon
23 0.867 False 81.190493 0.737131 log 18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 84.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.7103	13	15.933	False	79.885937	0.738036	epsilon
18 1.327 False 83.420795 0.736923 log 21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.56577	10	2.197	False	82.538558	0.737964	epsilon
21 1.140 False 82.468896 0.735949 log 1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	23	0.867	False	81.190493	0.737131	log
1 1.660 False 97.099984 0.735186 learning rate 0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	18	1.327	False	83.420795	0.736923	log
0 5.061 False 97.099984 0.735186 all features 15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	21	1.140	False	82.468896	0.735949	log
15 0.878 False 83.854123 0.735117 log 8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	1	1.660	False	97.099984	0.735186	learning rate
8 0.522 False 94.274794 0.734561 epsilon 16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	0	5.061	False	97.099984	0.735186	all features
16 1.237 False 87.890446 0.734283 log 20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	15	0.878	False	83.854123	0.735117	log
20 0.812 False 85.514273 0.732755 log 17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	8	0.522	False	94.274794	0.734561	epsilon
17 1.434 False 85.180434 0.730737 log 6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	16	1.237	False	87.890446	0.734283	log
6 0.151 False 134.658479 0.729835 epsilon 3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	20	0.812	False	85.514273	0.732755	log
3 0.605 False 80.126535 0.729210 learning rate 7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	17	1.434	False	85.180434	0.730737	log
7 0.365 False 109.385158 0.728721 epsilon 14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	6	0.151	False	134.658479	0.729835	epsilon
14 1.117 False 86.710362 0.725452 log 4 0.044 False 98.565776 0.536584 learning rate	3	0.605	False	80.126535	0.729210	learning rate
4 0.044 False 98.565776 0.536584 learning rate	7	0.365	False	109.385158	0.728721	epsilon
9	14	1.117	False	86.710362	0.725452	log
5 0.001 False 99.809458 0.535056 learning rate	4	0.044	False	98.565776	0.536584	learning rate
	5	0.001	False	99.809458	0.535056	learning rate

[75]: show_sorted_model(model_data)

[75]:	model_name	description
1	19 ww	log Total phenols
2	24 ww	log Total phenols-Proanthocyanins
1	L1 ww	whole model-epsilon:1e-07
1	l2 ww	whole model-epsilon:1e-08
2	22 ww	log Proanthocyanins
2	2 ww	whole model-lr:lr_type.iteration_plus_one
S	ww e	whole model-epsilon:1e-05
1	L3 ww	whole model-epsilon:1e-09
1	LO ww	whole model-epsilon:1e-06
2	23 ww	log Hue
1	L8 ww	log Magnesium
2	21 ww	log Nonflavanoid phenols
1	L ww	whole model-lr:lr_type.iteration
C) ww	whole model
1	L5 ww	log Malic acid
8	S ww	whole model-epsilon:0.0001
1	L6 ww	log Ash
2	20 ww	log Flavanoids
1	L7 ww	log Alkalinity of ash

```
6
                                  whole model-epsilon:0.01
           WW
3
                        whole model-lr:lr_type.sample_size
           ww
7
           ww
                                 whole model-epsilon:0.001
14
                                                log Alcohol
           ww
4
                    whole model-lr:lr_type.ten_sample_size
           TAT TAT
5
               whole model-lr:lr_type.hundred_sample_size
                  learning_rate iteration \
     lr type.iteration plus one
                                       2743
19
24
     lr_type.iteration_plus_one
                                       2523
     lr type.iteration plus one
11
                                     10464
12
     lr_type.iteration_plus_one
                                     19610
22
     lr type.iteration plus one
                                       2439
2
     lr_type.iteration_plus_one
                                       2753
9
     lr_type.iteration_plus_one
                                       2753
13
     lr_type.iteration_plus_one
                                     36990
     lr_type.iteration_plus_one
10
                                       5496
23
     lr_type.iteration_plus_one
                                       2118
18
     lr_type.iteration_plus_one
                                       2205
21
     lr_type.iteration_plus_one
                                       1844
1
              lr_type.iteration
                                       4032
0
              lr type.iteration
                                       4032
15
     lr_type.iteration_plus_one
                                       2115
8
     lr type.iteration plus one
                                       1263
16
     lr type.iteration plus one
                                       3062
20
     lr type.iteration plus one
                                       1934
17
     lr_type.iteration_plus_one
                                       2904
6
     lr_type.iteration_plus_one
                                        235
3
            lr_type.sample_size
                                       1362
7
     lr_type.iteration_plus_one
                                       531
14
     lr_type.iteration_plus_one
                                       2469
4
                                        74
        lr_type.ten_sample_size
5
    lr_type.hundred_sample_size
                                          2
                                                               epsilon \
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                                                                           variable
                                               loss
                                                     accuracy_kfold
      19
                 1.102
                                 False
                                          85.723087
                                                           0.742064
                                                                                 log
      24
                 1.572
                                 False
                                          84.807459
                                                           0.740256
                                                                                 log
                                                                            epsilon
      11
                 4.588
                                 False
                                          80.926339
                                                           0.739631
      12
                 7.677
                                 False
                                          80.216146
                                                           0.739354
                                                                            epsilon
      22
                 0.991
                                 False
                                          85.158078
                                                           0.738938
                                                                                 log
      2
                 1.110
                                 False
                                          86.235038
                                                           0.738105
                                                                      learning rate
      9
                                 False
                                                                            epsilon
                 1.104
                                          86.235038
                                                           0.738105
      13
                15.933
                                 False
                                          79.885937
                                                                            epsilon
                                                           0.738036
                                 False
                                                           0.737964
      10
                 2.197
                                          82.538558
                                                                            epsilon
      23
                 0.867
                                 False
                                          81.190493
                                                           0.737131
                                                                                 log
      18
                 1.327
                                 False
                                          83.420795
                                                           0.736923
                                                                                 log
                                 False
      21
                  1.140
                                          82.468896
                                                           0.735949
                                                                                 log
      1
                 1.660
                                 False
                                                                      learning rate
                                          97.099984
                                                           0.735186
      0
                 5.061
                                 False
                                          97.099984
                                                           0.735186
                                                                       all features
      15
                 0.878
                                 False
                                          83.854123
                                                           0.735117
                                                                                 log
      8
                                 False
                 0.522
                                          94.274794
                                                           0.734561
                                                                            epsilon
      16
                  1.237
                                 False
                                          87.890446
                                                           0.734283
                                                                                 log
      20
                                 False
                 0.812
                                          85.514273
                                                           0.732755
                                                                                 log
      17
                  1.434
                                 False
                                          85.180434
                                                           0.730737
                                                                                 log
      6
                 0.151
                                 False
                                        134.658479
                                                                            epsilon
                                                           0.729835
      3
                 0.605
                                 False
                                          80.126535
                                                           0.729210
                                                                      learning rate
      7
                 0.365
                                 False 109.385158
                                                           0.728721
                                                                            epsilon
      14
                 1.117
                                 False
                                                                                log
                                          86.710362
                                                           0.725452
      4
                 0.044
                                 False
                                          98.565776
                                                                      learning rate
                                                           0.536584
      5
                 0.001
                                 False
                                                                      learning rate
                                          99.809458
                                                           0.535056
[76]: #check for removing variables
      for i in range(ww_x_train_logpp.shape[1]):
          print (i,',column=>',ww_columns[i])
          ww_x_train_modified = np.delete(ww_x_train_logpp.to_numpy(), [i], 1)
          title = 'log Total phen-Proan-no {}'.format(ww_columns[i])
```

```
0 ,column=> Alcohol
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Malic acid
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> Ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
3 ,column=> Alkalinity of ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
```

```
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> Magnesium
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Total phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> Flavanoids
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
7 ,column=> Nonflavanoid phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
```

```
8 ,column=> Proanthocyanins
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     9 ,column=> Hue
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[76]:
         model_name
                                                      description \
      19
                                                log Total phenols
     24
                                log Total phenols-Proanthocyanins
                 WW
      11
                                        whole model-epsilon:1e-07
                 ww
     12
                                        whole model-epsilon:1e-08
                 WW
                                              log Proanthocyanins
      22
                 WW
     28
                        log Total phen-Proan-no Alkalinity of ash
                 WW
     2
                        whole model-lr:lr_type.iteration_plus_one
                 WW
     9
                                        whole model-epsilon:1e-05
      13
                                        whole model-epsilon:1e-09
      10
                                        whole model-epsilon:1e-06
                 ww
      23
                                                          log Hue
                 WW
      18
                                                    log Magnesium
                 WW
     27
                                      log Total phen-Proan-no Ash
                 WW
     29
                                log Total phen-Proan-no Magnesium
                 WW
     21
                                         log Nonflavanoid phenols
                                 whole model-lr:lr_type.iteration
      1
      0
                                                      whole model
                 WW
     15
                 ww
                                                   log Malic acid
      30
                            log Total phen-Proan-no Total phenols
                 WW
                                       whole model-epsilon:0.0001
     8
                 WW
     16
                                                          log Ash
                 WW
     20
                                                   log Flavanoids
     17
                                            log Alkalinity of ash
                 WW
```

```
6
                                     whole model-epsilon:0.01
           ww
3
                          whole model-lr:lr_type.sample_size
           WW
7
           ww
                                   whole model-epsilon:0.001
33
                     log Total phen-Proan-no Proanthocyanins
           WW
14
                                                  log Alcohol
           WW
26
                          log Total phen-Proan-no Malic acid
           WW
25
                             log Total phen-Proan-no Alcohol
           WW
34
                                  log Total phen-Proan-no Hue
           WW
31
                          log Total phen-Proan-no Flavanoids
32
               log Total phen-Proan-no Nonflavanoid phenols
           ww
4
                      whole model-lr:lr type.ten sample size
           ww
5
                 whole model-lr:lr_type.hundred_sample_size
           ww
                  learning_rate iteration \
19
     lr_type.iteration_plus_one
                                       2743
24
                                       2523
     lr_type.iteration_plus_one
     lr_type.iteration_plus_one
11
                                      10464
12
     lr_type.iteration_plus_one
                                      19610
22
     lr_type.iteration_plus_one
                                       2439
28
     lr_type.iteration_plus_one
                                       2267
2
     lr_type.iteration_plus_one
                                       2753
9
     lr type.iteration plus one
                                       2753
13
     lr_type.iteration_plus_one
                                      36990
10
     lr type.iteration plus one
                                       5496
     lr_type.iteration_plus_one
23
                                       2118
18
     lr type.iteration plus one
                                       2205
27
     lr_type.iteration_plus_one
                                       2961
29
     lr_type.iteration_plus_one
                                       2268
21
     lr_type.iteration_plus_one
                                       1844
1
                                       4032
              lr_type.iteration
0
              lr_type.iteration
                                       4032
15
     lr_type.iteration_plus_one
                                       2115
30
     lr_type.iteration_plus_one
                                       2199
8
     lr_type.iteration_plus_one
                                       1263
16
     lr_type.iteration_plus_one
                                       3062
20
     lr_type.iteration_plus_one
                                       1934
17
     lr_type.iteration_plus_one
                                       2904
6
     lr_type.iteration_plus_one
                                        235
3
            lr type.sample size
                                       1362
7
     lr_type.iteration_plus_one
                                        531
33
     lr type.iteration plus one
                                       2409
14
     lr_type.iteration_plus_one
                                       2469
26
     lr_type.iteration_plus_one
                                       2721
25
     lr_type.iteration_plus_one
                                       2146
34
     lr_type.iteration_plus_one
                                       1727
31
     lr_type.iteration_plus_one
                                       1994
32
                                       1612
     lr_type.iteration_plus_one
```

```
5
                                          2
    lr_type.hundred_sample_size
                                                weights
                                                               epsilon \
    [[11.472057505397014435], [-4.4349784278962545...
                                                        1.000000e-05
19
    [[11.571783751264503302], [-4.2273367710084355...
24
                                                        1.000000e-05
11
    [[9.087798687760632232], [-4.04964890730847365...
                                                        1.000000e-07
    [[8.305635754643900189], [-4.08145059850403449...
12
                                                        1.000000e-08
22
    [[12.136361209371475922], [-4.3072039982668131...
                                                        1.000000e-05
28
    [[8.850541831527898764], [-3.89118824863195484...
                                                        1.000000e-05
2
    [[12.1374092489669549964], [-4.520518798900213...
                                                        1.000000e-05
9
    [[12.1374092489669549964], [-4.520518798900213...
                                                        1.000000e-05
13
    [[7.7814651988257482708], [-4.1149838488482304...
                                                        1.000000e-09
10
    [[10.283574906574218732], [-4.1060086401810997...
                                                        1.000000e-06
    [[10.550083355026051274], [-4.1522402634849284...
                                                        1.000000e-05
23
    [[12.378667135942420577], [-5.2467260468350486...
18
                                                        1.000000e-05
    [[11.456849077578187573], [-2.8345242831094986...
27
                                                        1.000000e-05
29
    [[14.073646908470692887], [-5.5047098570100916...
                                                        1.000000e-05
21
    [[7.574352853182287649], [-4.53548774286644673...
                                                        1.000000e-05
    [[16.378906342486571375], [-5.5259574517590583...
                                                        1.000000e-05
1
    \hbox{\tt [[16.378906342486571375], [-5.5259574517590583...} \\
0
                                                        1.000000e-05
    [[10.097329325595773509], [-0.4022719394966720...
                                                        1.000000e-05
15
    [[12.710324024997548719], [-4.8963523723579962...
30
                                                        1.000000e-05
    [[14.944116734687297383], [-5.9888301416859652...
                                                        1.000000e-04
8
    [[12.0433165615157943], [-3.423846932597623296...
                                                        1.000000e-05
16
20
    [[13.077075012640899667], [-5.3331788140696238...
                                                        1.000000e-05
    [[12.144219855790955124], [-5.0777700676349558...
                                                        1.000000e-05
17
6
    [[20.268681216307229112], [-17.891141982398493...
                                                        1.000000e-02
3
    [[3.239870586975073716], [-3.93183866315446415...
                                                        1.000000e-05
7
    [[18.400300481674902137], [-9.9749477354584466...
                                                        1.000000e-03
    [[6.573151944209476847], [-3.68075864668547587...
                                                        1.000000e-05
33
    [[1.2167490011416727461], [-3.4149019369519555...
14
                                                        1.000000e-05
    [[9.986283436440546812], [0.720063750748263452...
26
                                                        1.000000e-05
25
    [[-2.6197091200274779232], [1.9603738862527356...
                                                        1.000000e-05
34
    [[9.765787043289230331], [-5.42284373002951372...
                                                        1.000000e-05
31
    [[15.0500309728559125205], [-5.361661631222361...
                                                        1.000000e-05
    [[-1.0460067470590719306], [-4.565756503472974...
                                                        1.000000e-05
32
4
    [[0.07851626733184168337], [-0.114624863637962...
                                                        1.000000e-05
5
    [[0.00018731212820512820378], [-9.962399624765...
                                                        1.000000e-05
    elapsed_time is_max_reached
                                         loss
                                               accuracy_kfold
                                                                        variable
                                                                             log
19
           1.102
                           False
                                    85.723087
                                                      0.742064
24
           1.572
                           False
                                    84.807459
                                                      0.740256
                                                                             log
           4.588
                                    80.926339
                                                                         epsilon
11
                           False
                                                      0.739631
12
           7.677
                           False
                                    80.216146
                                                                         epsilon
                                                      0.739354
22
           0.991
                           False
                                    85.158078
                                                      0.738938
                                                                             log
28
           1.235
                           False
                                    84.164349
                                                      0.738384
                                                                feature removal
```

74

4

lr_type.ten_sample_size

```
2
            1.110
                            False
                                     86.235038
                                                        0.738105
                                                                     learning rate
9
            1.104
                            False
                                     86.235038
                                                        0.738105
                                                                           epsilon
13
           15.933
                            False
                                     79.885937
                                                        0.738036
                                                                           epsilon
10
            2.197
                            False
                                     82.538558
                                                        0.737964
                                                                           epsilon
23
            0.867
                            False
                                     81.190493
                                                        0.737131
                                                                                log
18
            1.327
                            False
                                     83.420795
                                                        0.736923
                                                                                log
                                                                   feature removal
27
            1.427
                            False
                                     86.799715
                                                        0.736504
29
            0.888
                            False
                                     83.367648
                                                        0.736227
                                                                   feature removal
21
            1.140
                            False
                                     82.468896
                                                        0.735949
                                                                                log
            1.660
                            False
                                     97.099984
1
                                                        0.735186
                                                                     learning rate
0
                            False
            5.061
                                     97.099984
                                                        0.735186
                                                                      all features
15
            0.878
                            False
                                     83.854123
                                                        0.735117
                                                                                log
30
            0.855
                            False
                                     85.039416
                                                        0.734769
                                                                   feature removal
8
            0.522
                            False
                                     94.274794
                                                        0.734561
                                                                           epsilon
                                                        0.734283
16
            1.237
                            False
                                     87.890446
                                                                                log
20
            0.812
                            False
                                     85.514273
                                                        0.732755
                                                                                log
17
            1.434
                            False
                                     85.180434
                                                        0.730737
                                                                                log
6
            0.151
                            False
                                    134.658479
                                                        0.729835
                                                                           epsilon
3
            0.605
                            False
                                     80.126535
                                                        0.729210
                                                                     learning rate
7
            0.365
                            False
                                    109.385158
                                                        0.728721
                                                                           epsilon
33
            1.363
                            False
                                     84.941279
                                                        0.728169
                                                                  feature removal
14
            1.117
                            False
                                     86.710362
                                                        0.725452
                                                                                log
26
            1.080
                            False
                                     86.886354
                                                        0.724344
                                                                  feature removal
25
                            False
            0.909
                                     85.443068
                                                        0.722117
                                                                   feature removal
34
            0.682
                            False
                                     84.911353
                                                                   feature removal
                                                        0.721982
31
            0.825
                            False
                                     86.027563
                                                        0.720732
                                                                  feature removal
32
            0.645
                            False
                                     86.142293
                                                        0.709404
                                                                  feature removal
4
            0.044
                            False
                                     98.565776
                                                        0.536584
                                                                     learning rate
5
            0.001
                            False
                                     99.809458
                                                        0.535056
                                                                     learning rate
```

[77]: model_data[model_data['variable'] == 'feature removal'].

sort_values(by=['accuracy_kfold'], ascending=False)

```
[77]:
                                                        description \
         model_name
      28
                         log Total phen-Proan-no Alkalinity of ash
                 WW
      27
                                       log Total phen-Proan-no Ash
                 WW
      29
                                 log Total phen-Proan-no Magnesium
                 WW
      30
                             log Total phen-Proan-no Total phenols
                 WW
      33
                           log Total phen-Proan-no Proanthocyanins
                 WW
      26
                                log Total phen-Proan-no Malic acid
                 ww
      25
                                   log Total phen-Proan-no Alcohol
                 WW
      34
                 ww
                                       log Total phen-Proan-no Hue
                                log Total phen-Proan-no Flavanoids
      31
                 WW
      32
                      log Total phen-Proan-no Nonflavanoid phenols
```

learning_rate iteration \ 28 lr_type.iteration_plus_one 2267

```
27
          lr_type.iteration_plus_one
                                            2961
      29
          lr_type.iteration_plus_one
                                            2268
      30
          lr_type.iteration_plus_one
                                            2199
      33
          lr_type.iteration_plus_one
                                            2409
          lr_type.iteration_plus_one
                                           2721
      26
      25
          lr_type.iteration_plus_one
                                            2146
      34
          lr_type.iteration_plus_one
                                            1727
      31
          lr_type.iteration_plus_one
                                            1994
          lr type.iteration plus one
      32
                                            1612
                                                      weights
                                                               epsilon elapsed_time
      28
          [[8.850541831527898764], [-3.89118824863195484...
                                                             0.00001
                                                                              1.235
      27
          [[11.456849077578187573], [-2.8345242831094986...
                                                             0.00001
                                                                              1.427
      29
          [[14.073646908470692887], [-5.5047098570100916...
                                                             0.00001
                                                                              0.888
          [[12.710324024997548719], [-4.8963523723579962...
      30
                                                             0.00001
                                                                              0.855
          [[6.573151944209476847], [-3.68075864668547587...
      33
                                                             0.00001
                                                                              1.363
          [[9.986283436440546812], [0.720063750748263452...
      26
                                                             0.00001
                                                                              1.080
      25
          [[-2.6197091200274779232], [1.9603738862527356...
                                                             0.00001
                                                                              0.909
          [[9.765787043289230331], [-5.42284373002951372...
                                                             0.00001
                                                                              0.682
          [[15.0500309728559125205], [-5.361661631222361...
                                                             0.00001
                                                                              0.825
      31
          [[-1.0460067470590719306], [-4.565756503472974...
                                                                              0.645
      32
                                                             0.00001
         is_max_reached
                                     accuracy_kfold
                                                             variable
                               loss
      28
                  False
                         84.164349
                                            0.738384
                                                      feature removal
      27
                  False 86.799715
                                            0.736504 feature removal
      29
                  False 83.367648
                                            0.736227 feature removal
                                            0.734769 feature removal
      30
                  False 85.039416
      33
                  False 84.941279
                                            0.728169 feature removal
      26
                  False 86.886354
                                            0.724344 feature removal
      25
                  False 85.443068
                                            0.722117 feature removal
      34
                  False 84.911353
                                            0.721982 feature removal
      31
                  False
                         86.027563
                                            0.720732 feature removal
      32
                  False
                         86.142293
                                            0.709404 feature removal
     show_sorted_model(model_data)
[78]:
         model_name
                                                        description \
      19
                                                  log Total phenols
                 WW
      24
                                 log Total phenols-Proanthocyanins
                 ww
      11
                                         whole model-epsilon:1e-07
                 ww
      12
                                         whole model-epsilon:1e-08
                 WW
      22
                 ww
                                                log Proanthocyanins
                         log Total phen-Proan-no Alkalinity of ash
      28
                 ww
      2
                         whole model-lr:lr_type.iteration_plus_one
                 ww
      9
                                         whole model-epsilon:1e-05
                 ww
      13
                                         whole model-epsilon:1e-09
                 ww
      10
                                         whole model-epsilon:1e-06
                 ww
```

```
23
                                                       log Hue
           WW
18
                                                log Magnesium
27
           ww
                                 log Total phen-Proan-no Ash
29
                           log Total phen-Proan-no Magnesium
           WW
21
                                     log Nonflavanoid phenols
           WW
1
                            whole model-lr:lr_type.iteration
           WW
0
                                                  whole model
           WW
15
                                               log Malic acid
           WW
30
                       log Total phen-Proan-no Total phenols
8
                                  whole model-epsilon:0.0001
           WW
16
           WW
                                                       log Ash
20
                                               log Flavanoids
           ww
17
                                        log Alkalinity of ash
           WW
6
                                     whole model-epsilon:0.01
           WW
3
                          whole model-lr:lr_type.sample_size
           WW
7
                                    whole model-epsilon:0.001
33
                     log Total phen-Proan-no Proanthocyanins
           WW
14
           ww
                                                  log Alcohol
26
                          log Total phen-Proan-no Malic acid
           ww
25
                             log Total phen-Proan-no Alcohol
           WW
34
           ww
                                  log Total phen-Proan-no Hue
31
                          log Total phen-Proan-no Flavanoids
           WW
32
                log Total phen-Proan-no Nonflavanoid phenols
           WW
4
                      whole model-lr:lr type.ten sample size
           ww
5
                  whole model-lr:lr_type.hundred_sample_size
           ww
                   learning_rate iteration
19
     lr_type.iteration_plus_one
                                       2743
24
     lr_type.iteration_plus_one
                                       2523
                                      10464
11
     lr_type.iteration_plus_one
12
     lr_type.iteration_plus_one
                                      19610
22
     lr_type.iteration_plus_one
                                       2439
28
     lr_type.iteration_plus_one
                                       2267
2
                                       2753
     lr_type.iteration_plus_one
9
     lr_type.iteration_plus_one
                                       2753
13
     lr_type.iteration_plus_one
                                      36990
10
                                       5496
     lr_type.iteration_plus_one
23
     lr_type.iteration_plus_one
                                       2118
18
     lr type.iteration plus one
                                       2205
27
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29
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0
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              lr_type.iteration
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     lr_type.iteration_plus_one
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30
     lr_type.iteration_plus_one
                                       2199
8
     lr_type.iteration_plus_one
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```

```
16
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20
     lr_type.iteration_plus_one
                                      1934
     lr_type.iteration_plus_one
17
                                      2904
6
     lr_type.iteration_plus_one
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3
            lr_type.sample_size
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     lr_type.iteration_plus_one
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     lr_type.iteration_plus_one
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     lr_type.iteration_plus_one
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     lr type.iteration plus one
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     lr_type.iteration_plus_one
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     lr type.iteration plus one
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     lr_type.iteration_plus_one
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4 [[0.07851626733184168337], [-0.114624863637962... 1.000000e-05
5 [[0.00018731212820512820378], [-9.962399624765... 1.000000e-05
```

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19	1.102	False	85.723087	0.742064	log
24	1.572	False	84.807459	0.740256	log
11	4.588	False	80.926339	0.739631	epsilon
12	7.677	False	80.216146	0.739354	epsilon
22	0.991	False	85.158078	0.738938	log
28	1.235	False	84.164349	0.738384	feature removal
2	1.110	False	86.235038	0.738105	learning rate
9	1.104	False	86.235038	0.738105	epsilon
13	15.933	False	79.885937	0.738036	epsilon
10	2.197	False	82.538558	0.737964	epsilon
23	0.867	False	81.190493	0.737131	log
18	1.327	False	83.420795	0.736923	log
27	1.427	False	86.799715	0.736504	feature removal
29	0.888	False	83.367648	0.736227	feature removal
21	1.140	False	82.468896	0.735949	log
1	1.660	False	97.099984	0.735186	learning rate
0	5.061	False	97.099984	0.735186	all features
15	0.878	False	83.854123	0.735117	log
30	0.855	False	85.039416	0.734769	feature removal
8	0.522	False	94.274794	0.734561	epsilon
16	1.237	False	87.890446	0.734283	log
20	0.812	False	85.514273	0.732755	log
17	1.434	False	85.180434	0.730737	log
6	0.151	False	134.658479	0.729835	epsilon
3	0.605	False	80.126535	0.729210	learning rate
7	0.365	False	109.385158	0.728721	epsilon
33	1.363	False	84.941279	0.728169	feature removal
14	1.117	False	86.710362	0.725452	log
26	1.080	False	86.886354	0.724344	feature removal
25	0.909	False	85.443068	0.722117	feature removal
34	0.682	False	84.911353	0.721982	feature removal
31	0.825	False	86.027563	0.720732	feature removal
32	0.645	False	86.142293	0.709404	feature removal
4	0.044	False	98.565776	0.536584	learning rate
5	0.001	False	99.809458	0.535056	learning rate

```
[79]: ww_x_finallog = pd.DataFrame(ww_x_train_logpp)
```

```
[80]: #test power 2 of features
for i in range(ww_x_finallog.shape[1]):
```

```
print (i,',column=>',ww_columns[i])
    x_train_power = power_n_feature(ww_x_finallog,i,2).to_numpy()
    title = 'log Total phen-Proan-*2 {}'.format(ww_columns[i])
    print(title)
    model_data = run_model('ww',title,learning_rate = 0, learning_rate_type = __
 Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                       epsilon = 1e-5,x_train = x_train_power , y_train =
 →ww_y_train , model_data = model_data, variable = 'power*2')
show_sorted_model(model_data)
0 ,column=> Alcohol
log Total phen-Proan-*2 Alcohol
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Malic acid
log Total phen-Proan-*2 Malic acid
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> Ash
log Total phen-Proan-*2 Ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
```

i====> 7 i====> 8 i====> 9

```
3 ,column=> Alkalinity of ash
log Total phen-Proan-*2 Alkalinity of ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> Magnesium
log Total phen-Proan-*2 Magnesium
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Total phenols
log Total phen-Proan-*2 Total phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> Flavanoids
log Total phen-Proan-*2 Flavanoids
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
```

```
log Total phen-Proan-*2 Nonflavanoid phenols
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     8 ,column=> Proanthocyanins
     log Total phen-Proan-*2 Proanthocyanins
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     9 ,column=> Hue
     log Total phen-Proan-*2 Hue
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[80]:
        model_name
                                                    description \
     19
                                              log Total phenols
                ww
     38
                       log Total phen-Proan-*2 Alkalinity of ash
                ww
                               log Total phen-Proan-*2 Magnesium
     39
                WW
     24
                ww
                               log Total phenols-Proanthocyanins
     40
                           log Total phen-Proan-*2 Total phenols
                ww
                                      whole model-epsilon:1e-07
     11
                ww
     12
                                      whole model-epsilon:1e-08
                WW
     41
                              log Total phen-Proan-*2 Flavanoids
                WW
     22
                                            log Proanthocyanins
                WW
```

7 ,column=> Nonflavanoid phenols

```
28
                  log Total phen-Proan-no Alkalinity of ash
           WW
9
                                   whole model-epsilon:1e-05
           WW
2
           ww
                  whole model-lr:lr_type.iteration_plus_one
13
                                   whole model-epsilon:1e-09
           WW
10
                                   whole model-epsilon:1e-06
           WW
23
                                                      log Hue
           WW
18
                                                log Magnesium
27
                                 log Total phen-Proan-no Ash
29
                           log Total phen-Proan-no Magnesium
36
                          log Total phen-Proan-*2 Malic acid
21
                                    log Nonflavanoid phenols
35
                             log Total phen-Proan-*2 Alcohol
           ww
37
                                 log Total phen-Proan-*2 Ash
           WW
0
                                                  whole model
           WW
1
                            whole model-lr:lr_type.iteration
           WW
15
                                               log Malic acid
30
                       log Total phen-Proan-no Total phenols
           WW
8
           ww
                                  whole model-epsilon:0.0001
16
           ww
                                                      log Ash
42
               log Total phen-Proan-*2 Nonflavanoid phenols
           WW
20
           WW
                                               log Flavanoids
17
                                       log Alkalinity of ash
           WW
6
                                    whole model-epsilon:0.01
3
                          whole model-lr:lr type.sample size
7
                                   whole model-epsilon:0.001
33
                     log Total phen-Proan-no Proanthocyanins
           WW
                                 log Total phen-Proan-*2 Hue
           ww
43
                     log Total phen-Proan-*2 Proanthocyanins
           ww
14
                                                  log Alcohol
           WW
26
                          log Total phen-Proan-no Malic acid
25
                             log Total phen-Proan-no Alcohol
34
           WW
                                 log Total phen-Proan-no Hue
31
                          log Total phen-Proan-no Flavanoids
           WW
32
               log Total phen-Proan-no Nonflavanoid phenols
           WW
4
                      whole model-lr:lr_type.ten_sample_size
           WW
5
                 whole model-lr:lr_type.hundred_sample_size
           WW
                  learning_rate iteration
19
     lr type.iteration plus one
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38
     lr_type.iteration_plus_one
                                      2318
39
     lr_type.iteration_plus_one
                                      2387
24
     lr_type.iteration_plus_one
                                      2523
40
     lr_type.iteration_plus_one
                                      3546
                                      10464
11
     lr_type.iteration_plus_one
12
     lr_type.iteration_plus_one
                                     19610
41
     lr_type.iteration_plus_one
                                      2133
22
     lr_type.iteration_plus_one
                                      2439
```

```
2267
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2
     lr_type.iteration_plus_one
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13
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     lr_type.iteration_plus_one
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23
     lr_type.iteration_plus_one
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18
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                                      2205
27
     lr_type.iteration_plus_one
                                      2961
29
     lr type.iteration plus one
                                      2268
36
     lr_type.iteration_plus_one
                                      2722
21
     lr type.iteration plus one
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     lr_type.iteration_plus_one
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37
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0
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1
                                      4032
              lr_type.iteration
15
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30
     lr_type.iteration_plus_one
                                      2199
8
     lr_type.iteration_plus_one
                                      1263
     lr_type.iteration_plus_one
16
                                      3062
42
     lr_type.iteration_plus_one
                                      2058
20
     lr_type.iteration_plus_one
                                      1934
17
     lr type.iteration plus one
                                      2904
6
     lr_type.iteration_plus_one
                                       235
3
            lr type.sample size
                                      1362
7
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     lr_type.iteration_plus_one
33
                                      2409
44
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     lr_type.iteration_plus_one
                                      3611
14
     lr_type.iteration_plus_one
                                      2469
26
     lr_type.iteration_plus_one
                                      2721
25
     lr_type.iteration_plus_one
                                      2146
34
     lr_type.iteration_plus_one
                                      1727
31
     lr_type.iteration_plus_one
                                      1994
32
     lr_type.iteration_plus_one
                                      1612
4
        lr_type.ten_sample_size
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5
    lr_type.hundred_sample_size
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                                                              epsilon \
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                                                                        variable
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                                                      0.742064
                                                                              log
38
           0.951
                           False
                                    85.247168
                                                      0.741300
                                                                         power*2
39
           0.980
                           False
                                    84.223758
                                                      0.741162
                                                                         power*2
24
           1.572
                           False
                                    84.807459
                                                      0.740256
                                                                              log
40
           1.775
                           False
                                    92.024182
                                                      0.740187
                                                                         power*2
                                    80.926339
11
           4.588
                           False
                                                      0.739631
                                                                         epsilon
12
           7.677
                           False
                                    80.216146
                                                                         epsilon
                                                      0.739354
41
                                                                         power*2
           0.883
                           False
                                    84.169551
                                                      0.739354
22
           0.991
                           False
                                    85.158078
                                                      0.738938
                                                                              log
```

```
28
            1.235
                            False
                                     84.164349
                                                       0.738384
                                                                  feature removal
9
            1.104
                            False
                                     86.235038
                                                       0.738105
                                                                           epsilon
2
            1.110
                            False
                                     86.235038
                                                       0.738105
                                                                    learning rate
13
           15.933
                            False
                                     79.885937
                                                       0.738036
                                                                           epsilon
10
            2.197
                            False
                                     82.538558
                                                       0.737964
                                                                           epsilon
23
           0.867
                            False
                                     81.190493
                                                       0.737131
                                                                               log
18
            1.327
                            False
                                     83.420795
                                                       0.736923
                                                                               log
27
            1.427
                            False
                                     86.799715
                                                       0.736504
                                                                  feature removal
29
            0.888
                            False
                                     83.367648
                                                       0.736227
                                                                  feature removal
36
            1.425
                            False
                                     85.761598
                                                       0.736157
                                                                           power*2
21
                            False
                                     82.468896
            1.140
                                                       0.735949
                                                                               log
35
            1.016
                            False
                                     84.943099
                                                       0.735532
                                                                           power*2
37
            1.107
                            False
                                     85.890549
                                                       0.735323
                                                                           power*2
0
           5.061
                            False
                                     97.099984
                                                       0.735186
                                                                     all features
1
            1.660
                            False
                                     97.099984
                                                       0.735186
                                                                    learning rate
15
            0.878
                            False
                                     83.854123
                                                       0.735117
                                                                               log
30
           0.855
                            False
                                     85.039416
                                                       0.734769
                                                                  feature removal
                                     94.274794
8
            0.522
                            False
                                                       0.734561
                                                                           epsilon
16
            1.237
                            False
                                     87.890446
                                                       0.734283
                                                                               log
42
            0.833
                            False
                                     84.638295
                                                                           power*2
                                                       0.733376
20
            0.812
                            False
                                     85.514273
                                                       0.732755
                                                                               log
                                     85.180434
17
                            False
            1.434
                                                       0.730737
                                                                               log
6
            0.151
                            False
                                   134.658479
                                                       0.729835
                                                                           epsilon
3
                            False
           0.605
                                     80.126535
                                                       0.729210
                                                                    learning rate
7
            0.365
                            False
                                    109.385158
                                                                           epsilon
                                                       0.728721
33
            1.363
                            False
                                     84.941279
                                                       0.728169
                                                                  feature removal
                            False
                                                                           power*2
44
            0.919
                                     85.532771
                                                       0.727539
43
                            False
                                     91.446068
                                                       0.726500
            1.697
                                                                           power*2
14
            1.117
                            False
                                     86.710362
                                                       0.725452
                                                                               log
26
                                     86.886354
            1.080
                            False
                                                       0.724344
                                                                  feature removal
25
            0.909
                            False
                                     85.443068
                                                       0.722117
                                                                  feature removal
34
            0.682
                            False
                                     84.911353
                                                       0.721982
                                                                  feature removal
31
            0.825
                            False
                                     86.027563
                                                       0.720732
                                                                  feature removal
32
            0.645
                            False
                                     86.142293
                                                       0.709404
                                                                  feature removal
4
            0.044
                            False
                                     98.565776
                                                       0.536584
                                                                    learning rate
5
            0.001
                            False
                                     99.809458
                                                       0.535056
                                                                    learning rate
```

i====> 0

```
i====> 1
     i====>
              2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[81]:
         model_name
                                                       description
      19
                 WW
                                                 log Total phenols
     45
                        log Total phen/Proan-*2 Alkalinity of ash
                 WW
     38
                 ww
                        log Total phen-Proan-*2 Alkalinity of ash
                                 log Total phen-Proan-*2 Magnesium
     39
                 WW
     24
                                 log Total phenols-Proanthocyanins
                 ww
      40
                            log Total phen-Proan-*2 Total phenols
                                         whole model-epsilon:1e-07
      11
      12
                                         whole model-epsilon:1e-08
                 ww
     41
                                log Total phen-Proan-*2 Flavanoids
                 WW
     22
                                               log Proanthocyanins
      28
                        log Total phen-Proan-no Alkalinity of ash
                 WW
      2
                        whole model-lr:lr_type.iteration_plus_one
                 WW
     9
                                         whole model-epsilon:1e-05
      13
                                         whole model-epsilon:1e-09
      10
                                         whole model-epsilon:1e-06
                 WW
      23
                                                            log Hue
                 WW
     18
                                                     log Magnesium
      27
                                       log Total phen-Proan-no Ash
     29
                                log Total phen-Proan-no Magnesium
                               log Total phen-Proan-*2 Malic acid
     36
                 ww
     21
                                          log Nonflavanoid phenols
     35
                                   log Total phen-Proan-*2 Alcohol
      37
                                       log Total phen-Proan-*2 Ash
                 WW
      0
                                                       whole model
                 WW
                                 whole model-lr:lr_type.iteration
      1
                 WW
      15
                                                    log Malic acid
      30
                            log Total phen-Proan-no Total phenols
                 WW
      8
                                        whole model-epsilon:0.0001
      16
      42
                 ww
                     log Total phen-Proan-*2 Nonflavanoid phenols
     20
                                                    log Flavanoids
                 WW
      17
                                             log Alkalinity of ash
                 WW
      6
                                          whole model-epsilon:0.01
      3
                                whole model-lr:lr_type.sample_size
     7
                                         whole model-epsilon:0.001
     33
                          log Total phen-Proan-no Proanthocyanins
                 WW
```

```
44
                                 log Total phen-Proan-*2 Hue
           ww
43
                     log Total phen-Proan-*2 Proanthocyanins
           WW
14
           ww
                                                  log Alcohol
26
                          log Total phen-Proan-no Malic acid
           ww
25
                             log Total phen-Proan-no Alcohol
           WW
34
                                  log Total phen-Proan-no Hue
           WW
31
                          log Total phen-Proan-no Flavanoids
           WW
32
               log Total phen-Proan-no Nonflavanoid phenols
           WW
4
                      whole model-lr:lr type.ten sample size
           WW
5
                  whole model-lr:lr_type.hundred_sample_size
           ww
                  learning_rate iteration \
19
     lr type.iteration plus one
                                       2743
45
     lr_type.iteration_plus_one
                                       2318
38
     lr_type.iteration_plus_one
                                       2318
39
     lr_type.iteration_plus_one
                                       2387
     lr_type.iteration_plus_one
24
                                       2523
40
     lr_type.iteration_plus_one
                                       3546
     lr type.iteration_plus_one
11
                                      10464
12
     lr_type.iteration_plus_one
                                      19610
41
     lr_type.iteration_plus_one
                                       2133
22
     lr type.iteration plus one
                                       2439
28
     lr_type.iteration_plus_one
                                       2267
2
     lr type.iteration plus one
                                       2753
9
     lr type.iteration plus one
                                       2753
13
     lr type.iteration plus one
                                      36990
10
     lr_type.iteration_plus_one
                                       5496
23
     lr_type.iteration_plus_one
                                       2118
18
     lr_type.iteration_plus_one
                                       2205
27
     lr_type.iteration_plus_one
                                       2961
29
     lr_type.iteration_plus_one
                                       2268
36
     lr_type.iteration_plus_one
                                       2722
21
     lr_type.iteration_plus_one
                                       1844
35
                                       2334
     lr_type.iteration_plus_one
37
     lr_type.iteration_plus_one
                                       2738
0
              lr_type.iteration
                                       4032
1
              lr type.iteration
                                       4032
15
     lr_type.iteration_plus_one
                                       2115
30
     lr type.iteration plus one
                                       2199
8
     lr_type.iteration_plus_one
                                       1263
16
     lr type.iteration plus one
                                       3062
42
     lr_type.iteration_plus_one
                                       2058
20
     lr_type.iteration_plus_one
                                       1934
17
     lr_type.iteration_plus_one
                                       2904
6
     lr_type.iteration_plus_one
                                        235
3
            lr_type.sample_size
                                       1362
7
                                        531
     lr_type.iteration_plus_one
```

```
44
     lr type.iteration plus one
                                       1946
43
     lr_type.iteration_plus_one
                                       3611
14
     lr_type.iteration_plus_one
                                       2469
26
     lr_type.iteration_plus_one
                                       2721
25
     lr_type.iteration_plus_one
                                       2146
34
     lr_type.iteration_plus_one
                                       1727
31
     lr_type.iteration_plus_one
                                       1994
32
     lr type.iteration plus one
                                       1612
4
        lr_type.ten_sample_size
                                         74
5
                                          2
    lr type.hundred sample size
                                                weights
                                                               epsilon \
    [[11.472057505397014435], [-4.4349784278962545...
19
                                                       1.000000e-05
45
    [[10.780086339913878238], [-3.7216570283533134...
                                                       1.000000e-05
    [[10.780086339913878238], [-3.7216570283533134...
38
                                                       1.000000e-05
    [[11.915738960490262956], [-4.1662803858045918...
39
                                                       1.000000e-05
    [[11.571783751264503302], [-4.2273367710084355...
24
                                                       1.000000e-05
40
    [[16.757890297389447553], [-6.5489032844729216...
                                                       1.000000e-05
    [[9.087798687760632232], [-4.04964890730847365...
11
                                                       1.000000e-07
    [[8.305635754643900189], [-4.08145059850403449...
12
                                                       1.000000e-08
41
    [[12.931171030702525031], [-4.6407389412016888...
                                                       1.000000e-05
22
    [[12.136361209371475922], [-4.3072039982668131...
                                                       1.000000e-05
    [[8.850541831527898764], [-3.89118824863195484...
28
                                                       1.000000e-05
2
    [[12.1374092489669549964], [-4.520518798900213...
                                                       1.000000e-05
9
    [[12.1374092489669549964], [-4.520518798900213...
                                                       1.000000e-05
13
                                                       1.000000e-09
    [[7.7814651988257482708], [-4.1149838488482304...
    [[10.283574906574218732], [-4.1060086401810997...
10
                                                       1.000000e-06
23
    [[10.550083355026051274], [-4.1522402634849284...
                                                       1.000000e-05
18
    [[12.378667135942420577], [-5.2467260468350486...
                                                       1.000000e-05
27
    [[11.456849077578187573], [-2.8345242831094986...
                                                       1.000000e-05
29
    [[14.073646908470692887], [-5.5047098570100916...
                                                       1.000000e-05
36
    [[11.727506805508466206], [-8.7890367450832210...
                                                       1.000000e-05
21
    [[7.574352853182287649], [-4.53548774286644673...
                                                       1.000000e-05
35
    [[7.99809541520755354], [-3.900010977053474500...
                                                       1.000000e-05
37
    [[11.810775725772269145], [-3.8200989106924167...
                                                       1.000000e-05
0
    [[16.378906342486571375], [-5.5259574517590583...
                                                       1.000000e-05
1
    [[16.378906342486571375], [-5.5259574517590583...
                                                       1.000000e-05
    [[10.097329325595773509], [-0.4022719394966720...
15
                                                       1.000000e-05
30
    [[12.710324024997548719], [-4.8963523723579962...
                                                       1.000000e-05
    [[14.944116734687297383], [-5.9888301416859652...
8
                                                       1.000000e-04
16
    [[12.0433165615157943], [-3.423846932597623296...
                                                       1.000000e-05
    [[9.578820849453080831], [-4.04663715600940727...
42
                                                       1.000000e-05
20
    [[13.077075012640899667], [-5.3331788140696238...
                                                       1.000000e-05
    [[12.144219855790955124], [-5.0777700676349558...
17
                                                       1.000000e-05
    [[20.268681216307229112], [-17.891141982398493...
6
                                                       1.000000e-02
3
    [[3.239870586975073716], [-3.93183866315446415...
                                                       1.000000e-05
```

2409

33

lr_type.iteration_plus_one

```
7
    [[18.400300481674902137], [-9.9749477354584466... 1.000000e-03
    [[6.573151944209476847], [-3.68075864668547587... 1.000000e-05
33
    [[11.0619179243542326545], [-4.980700263316878... 1.000000e-05
    [[9.70288456997957947], [-4.517980142783009670... 1.000000e-05
43
14
    [[1.2167490011416727461], [-3.4149019369519555... 1.000000e-05
    [[9.986283436440546812], [0.720063750748263452... 1.000000e-05
26
    [[-2.6197091200274779232], [1.9603738862527356... 1.000000e-05
25
    [[9.765787043289230331], [-5.42284373002951372... 1.000000e-05
34
    [[15.0500309728559125205], [-5.361661631222361... 1.000000e-05
31
32
    [[-1.0460067470590719306], [-4.565756503472974... 1.000000e-05
    [[0.07851626733184168337], [-0.114624863637962... 1.000000e-05
4
5
    [[0.00018731212820512820378], [-9.962399624765... 1.000000e-05
```

	elapsed_time	is_max_reached	loss	accuracy_kfold	variable
19	1.102	False	85.723087	0.742064	log
45	0.991	False	85.247168	0.741300	power*2
38	0.951	False	85.247168	0.741300	power*2
39	0.980	False	84.223758	0.741162	power*2
24	1.572	False	84.807459	0.740256	log
40	1.775	False	92.024182	0.740187	power*2
11	4.588	False	80.926339	0.739631	epsilon
12	7.677	False	80.216146	0.739354	epsilon
41	0.883	False	84.169551	0.739354	power*2
22	0.991	False	85.158078	0.738938	log
28	1.235	False	84.164349	0.738384	feature removal
2	1.110	False	86.235038	0.738105	learning rate
9	1.104	False	86.235038	0.738105	epsilon
13	15.933	False	79.885937	0.738036	epsilon
10	2.197	False	82.538558	0.737964	epsilon
23	0.867	False	81.190493	0.737131	log
18	1.327	False	83.420795	0.736923	log
27	1.427	False	86.799715	0.736504	feature removal
29	0.888	False	83.367648	0.736227	feature removal
36	1.425	False	85.761598	0.736157	power*2
21	1.140	False	82.468896	0.735949	log
35	1.016	False	84.943099	0.735532	power*2
37	1.107	False	85.890549	0.735323	power*2
0	5.061	False	97.099984	0.735186	all features
1	1.660	False	97.099984	0.735186	learning rate
15	0.878	False	83.854123	0.735117	log
30	0.855	False	85.039416	0.734769	feature removal
8	0.522	False	94.274794	0.734561	epsilon
16	1.237	False	87.890446	0.734283	log
42	0.833	False	84.638295	0.733376	power*2
20	0.812	False	85.514273	0.732755	log
17	1.434	False	85.180434	0.730737	log
6	0.151	False	134.658479	0.729835	epsilon

```
0.605
      3
                                 False
                                         80.126535
                                                           0.729210
                                                                        learning rate
      7
                 0.365
                                        109.385158
                                 False
                                                           0.728721
                                                                              epsilon
      33
                 1.363
                                 False
                                         84.941279
                                                           0.728169
                                                                      feature removal
      44
                 0.919
                                 False
                                          85.532771
                                                           0.727539
                                                                              power*2
      43
                 1.697
                                 False
                                         91.446068
                                                           0.726500
                                                                              power*2
      14
                 1.117
                                 False
                                         86.710362
                                                           0.725452
                                                                                   log
      26
                 1.080
                                 False
                                         86.886354
                                                           0.724344
                                                                      feature removal
                                          85.443068
      25
                                 False
                 0.909
                                                           0.722117
                                                                      feature removal
      34
                                 False
                                         84.911353
                                                                      feature removal
                 0.682
                                                           0.721982
      31
                 0.825
                                 False
                                         86.027563
                                                                      feature removal
                                                           0.720732
      32
                                 False
                 0.645
                                         86.142293
                                                           0.709404
                                                                      feature removal
      4
                 0.044
                                 False
                                         98.565776
                                                           0.536584
                                                                        learning rate
      5
                 0.001
                                 False
                                          99.809458
                                                           0.535056
                                                                        learning rate
[82]: #alkalanity of ash-magnaseim as power2 test
      x_train_power2 = power_n_feature(ww_x_finallog,3,2).to_numpy()
      x_train_powerashmag = power_n_feature(pd.DataFrame(x_train_power2),4,2).
       →to numpy()
      model data = run model('ww','log Total phen/Proan-*2 Alkal of ash/
       mage',learning_rate = 0, learning_rate type = learning_rate type.
       ⇔iteration_plus_one ,max_iterations = 150000,
                              epsilon = 1e-5,x_train = x_train_powerashmag , y_train =_
       →ww_y_train , model_data = model_data, variable = 'power*2')
      show_sorted_model(model_data)
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[82]:
                                                        description \
         model_name
      19
                                                  log Total phenols
                 WW
                         log Total phen/Proan-*2 Alkal of ash/mage
      46
                 WW
                         log Total phen/Proan-*2 Alkalinity of ash
      45
                 WW
                         log Total phen-Proan-*2 Alkalinity of ash
      38
                 WW
      39
                 ww
                                 log Total phen-Proan-*2 Magnesium
      24
                                 log Total phenols-Proanthocyanins
                 WW
      40
                             log Total phen-Proan-*2 Total phenols
                 T<sub>4</sub>7 T<sub>4</sub>7
                                          whole model-epsilon:1e-07
      11
                 w
      12
                                          whole model-epsilon:1e-08
                 ww
      41
                                log Total phen-Proan-*2 Flavanoids
```

```
22
                                          log Proanthocyanins
           WW
28
                   log Total phen-Proan-no Alkalinity of ash
2
           ww
                   whole model-lr:lr_type.iteration_plus_one
9
                                   whole model-epsilon:1e-05
           WW
                                   whole model-epsilon:1e-09
13
           WW
10
                                   whole model-epsilon:1e-06
           ww
23
                                                      log Hue
18
                                                log Magnesium
           WW
27
                                 log Total phen-Proan-no Ash
29
                           log Total phen-Proan-no Magnesium
36
                          log Total phen-Proan-*2 Malic acid
21
                                    log Nonflavanoid phenols
           ww
35
                             log Total phen-Proan-*2 Alcohol
37
                                 log Total phen-Proan-*2 Ash
           Ta7 Ta7
0
                                                  whole model
           WW
1
                            whole model-lr:lr_type.iteration
15
                                               log Malic acid
           WW
30
                       log Total phen-Proan-no Total phenols
           ww
8
                                  whole model-epsilon:0.0001
           ww
16
                                                      log Ash
           WW
42
                log Total phen-Proan-*2 Nonflavanoid phenols
           w
20
                                               log Flavanoids
           WW
17
                                        log Alkalinity of ash
6
                                    whole model-epsilon:0.01
3
                          whole model-lr:lr_type.sample_size
7
                                   whole model-epsilon:0.001
33
                     log Total phen-Proan-no Proanthocyanins
           ww
44
                                 log Total phen-Proan-*2 Hue
           WW
43
                     log Total phen-Proan-*2 Proanthocyanins
           WW
14
                                                  log Alcohol
26
                          log Total phen-Proan-no Malic acid
25
                             log Total phen-Proan-no Alcohol
34
                                 log Total phen-Proan-no Hue
           WW
31
                          log Total phen-Proan-no Flavanoids
           WW
32
               log Total phen-Proan-no Nonflavanoid phenols
           WW
4
                      whole model-lr:lr_type.ten_sample_size
           WW
                 whole model-lr:lr_type.hundred_sample_size
5
           WW
                   learning rate iteration
19
     lr_type.iteration_plus_one
                                      2743
46
     lr_type.iteration_plus_one
                                      2189
     lr_type.iteration_plus_one
45
                                      2318
38
     lr_type.iteration_plus_one
                                      2318
39
                                      2387
     lr_type.iteration_plus_one
24
     lr_type.iteration_plus_one
                                      2523
40
                                      3546
     lr_type.iteration_plus_one
11
     lr_type.iteration_plus_one
                                      10464
```

```
12
                                     19610
     lr_type.iteration_plus_one
41
     lr_type.iteration_plus_one
                                      2133
22
     lr_type.iteration_plus_one
                                      2439
28
     lr_type.iteration_plus_one
                                      2267
2
     lr_type.iteration_plus_one
                                      2753
9
     lr_type.iteration_plus_one
                                      2753
13
     lr_type.iteration_plus_one
                                     36990
10
     lr_type.iteration_plus_one
                                      5496
23
     lr type.iteration plus one
                                      2118
18
     lr_type.iteration_plus_one
                                      2205
27
     lr type.iteration plus one
                                      2961
29
     lr_type.iteration_plus_one
                                      2268
36
     lr type.iteration plus one
                                      2722
     lr_type.iteration_plus_one
21
                                      1844
35
     lr_type.iteration_plus_one
                                      2334
37
     lr_type.iteration_plus_one
                                      2738
0
              lr_type.iteration
                                      4032
1
              lr_type.iteration
                                      4032
15
     lr_type.iteration_plus_one
                                      2115
30
     lr_type.iteration_plus_one
                                      2199
8
     lr_type.iteration_plus_one
                                      1263
16
     lr type.iteration plus one
                                      3062
42
     lr_type.iteration_plus_one
                                      2058
20
     lr type.iteration plus one
                                      1934
17
     lr_type.iteration_plus_one
                                      2904
6
     lr_type.iteration_plus_one
                                       235
3
            lr_type.sample_size
                                      1362
7
     lr_type.iteration_plus_one
                                       531
33
     lr_type.iteration_plus_one
                                      2409
44
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     lr_type.iteration_plus_one
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                                                                       variable
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                                   85.723087
                                                     0.742064
                           False
                                                                             log
                                                                        power*2
46
           0.920
                           False
                                   84.803401
                                                     0.741992
45
           0.991
                           False
                                   85.247168
                                                     0.741300
                                                                        power*2
38
           0.951
                           False
                                   85.247168
                                                     0.741300
                                                                        power*2
```

39	0.980	False	84.223758	0.741162	power*2
24	1.572	False	84.807459	0.740256	log
40	1.775	False	92.024182	0.740187	power*2
11	4.588	False	80.926339	0.739631	epsilon
12	7.677	False	80.216146	0.739354	epsilon
41	0.883	False	84.169551	0.739354	power*2
22	0.991	False	85.158078	0.738938	log
28	1.235	False	84.164349	0.738384	feature removal
2	1.110	False	86.235038	0.738105	learning rate
9	1.104	False	86.235038	0.738105	epsilon
13	15.933	False	79.885937	0.738036	epsilon
10	2.197	False	82.538558	0.737964	epsilon
23	0.867	False	81.190493	0.737131	log
18	1.327	False	83.420795	0.736923	log
27	1.427	False	86.799715	0.736504	feature removal
29	0.888	False	83.367648	0.736227	feature removal
36	1.425	False	85.761598	0.736157	power*2
21	1.140	False	82.468896	0.735949	log
35	1.016	False	84.943099	0.735532	power*2
37	1.107	False	85.890549	0.735323	power*2
0	5.061	False	97.099984	0.735186	all features
1	1.660	False	97.099984	0.735186	learning rate
15	0.878	False	83.854123	0.735117	log
30	0.855	False	85.039416	0.734769	feature removal
8	0.522	False	94.274794	0.734561	epsilon
16	1.237	False	87.890446	0.734283	log
42	0.833	False	84.638295	0.733376	power*2
20	0.812	False	85.514273	0.732755	log
17	1.434	False	85.180434	0.730737	log
6	0.151	False	134.658479	0.729835	epsilon
3	0.605	False	80.126535	0.729210	learning rate
7	0.365	False	109.385158	0.728721	epsilon
33	1.363	False	84.941279	0.728169	feature removal
44	0.919	False	85.532771	0.727539	power*2
43	1.697	False	91.446068	0.726500	power*2
14	1.117	False	86.710362	0.725452	log
26	1.080	False	86.886354	0.724344	feature removal
25	0.909	False	85.443068	0.722117	feature removal
34	0.682	False	84.911353	0.721982	feature removal
31	0.825	False	86.027563	0.720732	feature removal
32	0.645	False	86.142293	0.709404	feature removal
4	0.044	False	98.565776	0.536584	learning rate
5	0.001	False	99.809458	0.535056	learning rate

[83]: for i in range(x_train_powerashmag.shape[1]):
 print (i,',column=>',ww_columns[i])

```
x_train_power3 = power_n_feature(pd.DataFrame(x_train_powerashmag),i,3).
  →to_numpy()
    title = 'log Total phen/Proan-*2 Alkal of ash/mage-*3 {}'.

→format(ww columns[i])
    print(title)
    model_data = run_model('ww',title,learning_rate = 0, learning_rate_type = u
  Glearning_rate_type.iteration_plus_one ,max_iterations = 150000,
                       epsilon = 1e-5,x_train = x_train_power3 , y_train =__
 ⇔ww_y_train , model_data = model_data, variable = 'power*3')
show_sorted_model(model_data)
0 ,column=> Alcohol
log Total phen/Proan-*2 Alkal of ash/mage-*3 Alcohol
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
1 ,column=> Malic acid
log Total phen/Proan-*2 Alkal of ash/mage-*3 Malic acid
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
2 ,column=> Ash
log Total phen/Proan-*2 Alkal of ash/mage-*3 Ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
```

```
i====> 9
3 ,column=> Alkalinity of ash
log Total phen/Proan-*2 Alkal of ash/mage-*3 Alkalinity of ash
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
4 ,column=> Magnesium
log Total phen/Proan-*2 Alkal of ash/mage-*3 Magnesium
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
5 ,column=> Total phenols
log Total phen/Proan-*2 Alkal of ash/mage-*3 Total phenols
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
i====> 9
6 ,column=> Flavanoids
log Total phen/Proan-*2 Alkal of ash/mage-*3 Flavanoids
i====> 0
i====> 1
i====> 2
i====> 3
i====> 4
i====> 5
i====> 6
i====> 7
i====> 8
```

```
i====> 9
     7 ,column=> Nonflavanoid phenols
     log Total phen/Proan-*2 Alkal of ash/mage-*3 Nonflavanoid phenols
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     8 ,column=> Proanthocyanins
     log Total phen/Proan-*2 Alkal of ash/mage-*3 Proanthocyanins
     <ipython-input-59-bea85ad8211b>:100: RuntimeWarning: overflow encountered in exp
      return 1 / (1 + np.exp(float128(-arg)))
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
     9 ,column=> Hue
     log Total phen/Proan-*2 Alkal of ash/mage-*3 Hue
     i====> 0
     i====> 1
     i====> 2
     i====> 3
     i====> 4
     i====> 5
     i====> 6
     i====> 7
     i====> 8
     i====> 9
[83]:
        model_name
                                                        description \
     19
                                                   log Total phenols
                           log Total phen/Proan-*2 Alkal of ash/mage
     46
                ww
     45
                           log Total phen/Proan-*2 Alkalinity of ash
                ww
                           log Total phen-Proan-*2 Alkalinity of ash
     38
                ww
     39
                                   log Total phen-Proan-*2 Magnesium
                ww
```

40		lan Tatal when /Duran wo Albal of oak/wana wo Alb
49	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 Ash
24	WW	log Total phenols-Proanthocyanins
40	WW	log Total phen-Proan-*2 Total phenols
52	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 T
11	WW	whole model-epsilon:1e-07
12	WW	whole model-epsilon:1e-08
41	WW	log Total phen-Proan-*2 Flavanoids
22	WW	log Proanthocyanins
51	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 M
28	WW	log Total phen-Proan-no Alkalinity of ash
50	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 A
9	ww	whole model-epsilon:1e-05
2	ww	whole model-lr:lr_type.iteration_plus_one
13	ww	whole model-epsilon:1e-09
10	ww	whole model-epsilon:1e-06
23	ww	log Hue
18	WW	log Magnesium
27		log Total phen-Proan-no Ash
29	WW	
	WW	log Total phen-Proan-no Magnesium
36	WW	log Total phen-Proan-*2 Malic acid
21	WW	log Nonflavanoid phenols
48	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 M
35	WW	log Total phen-Proan-*2 Alcohol
37	WW	log Total phen-Proan-*2 Ash
0	WW	whole model
1	WW	<pre>whole model-lr:lr_type.iteration</pre>
15	WW	log Malic acid
30	WW	log Total phen-Proan-no Total phenols
8	WW	whole model-epsilon:0.0001
47	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 A
16	ww	log Ash
42	ww	log Total phen-Proan-*2 Nonflavanoid phenols
20	ww	log Flavanoids
55	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 P
17	ww	log Alkalinity of ash
6	ww	whole model-epsilon:0.01
53	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 F
3	ww	whole model-lr:lr_type.sample_size
7	ww	whole model-epsilon:0.001
33		log Total phen-Proan-no Proanthocyanins
44	WW	-
	WW	log Total phen-Proan-*2 Hue
43	WW	log Total phen-Proan-*2 Proanthocyanins
14	WW	log Alcohol
54	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 N
26	WW	log Total phen-Proan-no Malic acid
56	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 Hue
25	WW	log Total phen-Proan-no Alcohol

```
34
                                      log Total phen-Proan-no Hue
           WW
31
                               log Total phen-Proan-no Flavanoids
           WW
32
           WW
                    log Total phen-Proan-no Nonflavanoid phenols
4
                           whole model-lr:lr_type.ten_sample_size
           ww
5
                       whole model-lr:lr_type.hundred_sample_size
           ww
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     lr_type.iteration_plus_one
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     lr_type.iteration_plus_one
```

```
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     lr type.iteration plus one
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26
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     lr type.iteration plus one
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34
     lr type.iteration plus one
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31
     lr_type.iteration_plus_one
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32
     lr_type.iteration_plus_one
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                                                                             log
46
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                           False
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                                                      0.741992
                                                                         power*2
45
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                           False
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                                                      0.741300
                                                                         power*2
38
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                                                                         power*2
39
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                           False
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                                                      0.741162
                                                                         power*2
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                           False
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                                                      0.739634
                                                                         power*3
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                           False
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                                                                         epsilon
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                                                                         epsilon
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                           False
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                           False
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                                                                         power*3
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                           False
                                    84.164349
                                                      0.738384
                                                                 feature removal
50
           0.929
                           False
                                    83.642757
                                                      0.738171
                                                                         power*3
```

9	1.104	False	86.235038	0.738105	epsilon
2	1.110	False	86.235038	0.738105	learning rate
13	15.933	False	79.885937	0.738036	epsilon
10	2.197	False	82.538558	0.737964	epsilon
23	0.867	False	81.190493	0.737131	log
18	1.327	False	83.420795	0.736923	log
27	1.427	False	86.799715	0.736504	feature removal
29	0.888	False	83.367648	0.736227	feature removal
36	1.425	False	85.761598	0.736157	power*2
21	1.140	False	82.468896	0.735949	log
48	0.945	False	85.927533	0.735740	power*3
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37	1.107	False	85.890549	0.735323	power*2
0	5.061	False	97.099984	0.735186	all features
1	1.660	False	97.099984	0.735186	learning rate
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8	0.522	False	94.274794	0.734561	epsilon
47	0.916	False	85.599770	0.734283	power*3
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42	0.833	False	84.638295	0.733376	power*2
20	0.812	False	85.514273	0.732755	log
55	4.129	False	84.697588	0.732476	power*3
17	1.434	False	85.180434	0.730737	log
6	0.151	False	134.658479	0.729835	epsilon
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7	0.365	False	109.385158	0.728721	epsilon
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44	0.919	False	85.532771	0.727539	power*2
43	1.697	False	91.446068	0.726500	power*2
14	1.117	False	86.710362	0.725452	log
54	0.631	False	85.404313	0.725387	power*3
26	1.080	False	86.886354	0.724344	feature removal
56	0.670	False	85.844925	0.722816	power*3
25	0.909	False	85.443068	0.722117	feature removal
34	0.682	False	84.911353	0.721982	feature removal
31	0.825	False	86.027563	0.720732	feature removal
32	0.645	False	86.142293	0.709404	feature removal
4	0.044	False	98.565776	0.536584	learning rate
5	0.001	False	99.809458	0.535056	learning rate

[84]: show_sorted_model(model_data)

45	WW	log Total phen/Proan-*2 Alkalinity of ash
38	WW	log Total phen-Proan-*2 Alkalinity of ash
39	ww	log Total phen-Proan-*2 Magnesium
49	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 Ash
		-
24	WW	log Total phenols-Proanthocyanins
40	WW	log Total phen-Proan-*2 Total phenols
52	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 T
11	WW	whole model-epsilon:1e-07
12	WW	whole model-epsilon:1e-08
41	ww	log Total phen-Proan-*2 Flavanoids
22	ww	log Proanthocyanins
51	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 M
28		
	WW	log Total phen-Proan-no Alkalinity of ash
50	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 A
9	WW	whole model-epsilon:1e-05
2	WW	<pre>whole model-lr:lr_type.iteration_plus_one</pre>
13	WW	whole model-epsilon:1e-09
10	ww	whole model-epsilon:1e-06
23	WW	log Hue
18		-
	WW	log Magnesium
27	WW	log Total phen-Proan-no Ash
29	WW	log Total phen-Proan-no Magnesium
36	WW	log Total phen-Proan-*2 Malic acid
21	WW	log Nonflavanoid phenols
48	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 M
35	WW	log Total phen-Proan-*2 Alcohol
37		
	WW	log Total phen-Proan-*2 Ash
0	WW	whole model
1	WW	whole model-lr:lr_type.iteration
15	WW	log Malic acid
30	WW	log Total phen-Proan-no Total phenols
8	WW	whole model-epsilon:0.0001
47	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 A
16	ww	log Ash
42	ww	log Total phen-Proan-*2 Nonflavanoid phenols
20	WW	log Flavanoids
55	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 P
17	WW	log Alkalinity of ash
6	WW	whole model-epsilon:0.01
53	WW	log Total phen/Proan-*2 Alkal of ash/mage-*3 F
3	ww	whole model-lr:lr_type.sample_size
7	ww	whole model-epsilon:0.001
33		
	WW	log Total phen-Proan-no Proanthocyanins
44	WW	log Total phen-Proan-*2 Hue
43	WW	log Total phen-Proan-*2 Proanthocyanins
14	WW	log Alcohol
54	ww	log Total phen/Proan-*2 Alkal of ash/mage-*3 N
		-

```
26
                               log Total phen-Proan-no Malic acid
           WW
56
                log Total phen/Proan-*2 Alkal of ash/mage-*3 Hue
           ww
25
           ww
                                  log Total phen-Proan-no Alcohol
34
                                      log Total phen-Proan-no Hue
           ww
31
                               log Total phen-Proan-no Flavanoids
           WW
32
                     log Total phen-Proan-no Nonflavanoid phenols
           WW
4
                           whole model-lr:lr_type.ten_sample_size
           ww
5
                       whole model-lr:lr_type.hundred_sample_size
           ww
                  learning rate iteration \
19
     lr type.iteration plus one
                                      2743
46
     lr_type.iteration_plus_one
                                      2189
45
     lr type.iteration plus one
                                      2318
38
     lr_type.iteration_plus_one
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                                      2387
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24
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1934
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     lr type.iteration plus one
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32
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                                               accuracy_kfold
                                                                        variable
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                                    85.723087
                                                      0.742064
                           False
                                                                             log
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           0.920
                           False
                                    84.803401
                                                      0.741992
                                                                         power*2
45
           0.991
                                    85.247168
                           False
                                                      0.741300
                                                                         power*2
38
           0.951
                           False
                                    85.247168
                                                      0.741300
                                                                         power*2
39
           0.980
                           False
                                    84.223758
                                                      0.741162
                                                                         power*2
                           False
49
           0.966
                                    85.998220
                                                      0.740397
                                                                         power*3
24
           1.572
                           False
                                    84.807459
                                                      0.740256
                                                                             log
40
           1.775
                           False
                                    92.024182
                                                      0.740187
                                                                         power*2
52
           1.208
                           False
                                    89.686677
                                                      0.739634
                                                                         power*3
                                    80.926339
11
           4.588
                           False
                                                      0.739631
                                                                         epsilon
12
           7.677
                           False
                                    80.216146
                                                                         epsilon
                                                      0.739354
41
                                                                         power*2
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                           False
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                                                      0.739354
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           0.991
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                                    85.158078
                                                      0.738938
                                                                              log
```

```
51
            0.851
                            False
                                     83.504929
                                                        0.738726
                                                                            power*3
28
            1.235
                                     84.164349
                            False
                                                        0.738384
                                                                   feature removal
50
            0.929
                            False
                                     83.642757
                                                        0.738171
                                                                           power*3
9
            1.104
                            False
                                     86.235038
                                                        0.738105
                                                                            epsilon
2
            1.110
                            False
                                     86.235038
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                                                                     learning rate
13
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                            False
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                                                                            epsilon
10
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                                     81.190493
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                                                                                log
18
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                            False
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                                                                                log
                                                        0.736923
27
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            1.427
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                                                                   feature removal
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                            False
                                     84.943099
                                                                            power*2
            1.016
                                                        0.735532
37
            1.107
                            False
                                     85.890549
                                                        0.735323
                                                                            power*2
0
            5.061
                                                                      all features
                            False
                                     97.099984
                                                        0.735186
1
            1.660
                            False
                                     97.099984
                                                        0.735186
                                                                     learning rate
15
            0.878
                            False
                                     83.854123
                                                        0.735117
                                                                                log
30
            0.855
                            False
                                     85.039416
                                                        0.734769
                                                                   feature removal
8
            0.522
                            False
                                     94.274794
                                                        0.734561
                                                                            epsilon
47
            0.916
                            False
                                     85.599770
                                                        0.734283
                                                                            power*3
16
            1.237
                                     87.890446
                            False
                                                        0.734283
                                                                                log
                                                        0.733376
42
            0.833
                            False
                                     84.638295
                                                                            power*2
20
                            False
                                     85.514273
            0.812
                                                        0.732755
                                                                                log
55
            4.129
                            False
                                     84.697588
                                                        0.732476
                                                                           power*3
17
            1.434
                            False
                                     85.180434
                                                        0.730737
                                                                                log
6
                                    134.658479
            0.151
                            False
                                                        0.729835
                                                                            epsilon
53
            0.785
                            False
                                     86.114857
                                                        0.729417
                                                                            power*3
3
            0.605
                            False
                                     80.126535
                                                        0.729210
                                                                     learning rate
7
            0.365
                            False
                                    109.385158
                                                        0.728721
                                                                            epsilon
33
            1.363
                                     84.941279
                            False
                                                        0.728169
                                                                   feature removal
44
            0.919
                            False
                                     85.532771
                                                        0.727539
                                                                           power*2
43
            1.697
                            False
                                     91.446068
                                                        0.726500
                                                                            power*2
14
                                     86.710362
            1.117
                            False
                                                        0.725452
                                                                                log
54
            0.631
                            False
                                     85.404313
                                                                            power*3
                                                        0.725387
26
                                     86.886354
            1.080
                            False
                                                        0.724344
                                                                   feature removal
                            False
                                     85.844925
56
            0.670
                                                        0.722816
                                                                            power*3
25
            0.909
                            False
                                     85.443068
                                                        0.722117
                                                                   feature removal
34
            0.682
                            False
                                     84.911353
                                                        0.721982
                                                                   feature removal
31
            0.825
                            False
                                     86.027563
                                                        0.720732
                                                                   feature removal
32
            0.645
                            False
                                     86.142293
                                                        0.709404
                                                                   feature removal
4
            0.044
                            False
                                     98.565776
                                                        0.536584
                                                                     learning rate
5
            0.001
                                     99.809458
                            False
                                                        0.535056
                                                                     learning rate
```

```
[86]: import os
      cwd = os.getcwd()
      print(cwd)
     /content
[87]: model_data.loc[model_data['variable'] == 'epsilon']
                                      description
[87]:
         model_name
                                                                 learning_rate \
                        whole model-epsilon:0.01
      6
                                                   lr_type.iteration_plus_one
                 ww
      7
                 ww
                       whole model-epsilon:0.001
                                                   lr_type.iteration_plus_one
      8
                      whole model-epsilon:0.0001
                                                   lr_type.iteration_plus_one
                 WW
      9
                       whole model-epsilon:1e-05
                                                   lr_type.iteration_plus_one
                 ww
                       whole model-epsilon:1e-06
      10
                                                   lr_type.iteration_plus_one
                 ww
      11
                       whole model-epsilon:1e-07
                                                   lr_type.iteration_plus_one
                 ww
                       whole model-epsilon:1e-08
      12
                                                   lr_type.iteration_plus_one
                 WW
      13
                       whole model-epsilon:1e-09
                                                   lr_type.iteration_plus_one
                 ww
         iteration
                                                                 weights
                                                                                epsilon \
      6
               235
                     [[20.268681216307229112], [-17.891141982398493... 1.000000e-02
      7
               531
                     [[18.400300481674902137], [-9.9749477354584466...
                                                                        1.000000e-03
      8
              1263
                     [[14.944116734687297383], [-5.9888301416859652...
                                                                        1.000000e-04
              2753
                     [[12.1374092489669549964], [-4.520518798900213...
      9
                                                                        1.000000e-05
      10
              5496
                     [[10.283574906574218732], [-4.1060086401810997...
                                                                        1.000000e-06
                     [[9.087798687760632232], [-4.04964890730847365...
      11
             10464
                                                                        1.000000e-07
      12
             19610
                     [[8.305635754643900189], [-4.08145059850403449...
                                                                        1.000000e-08
                     [[7.7814651988257482708], [-4.1149838488482304...
      13
             36990
                                                                        1.000000e-09
          elapsed_time is_max_reached
                                               loss
                                                     accuracy_kfold variable
                 0.151
                                         134.658479
                                                                      epsilon
      6
                                 False
                                                            0.729835
      7
                 0.365
                                 False
                                         109.385158
                                                            0.728721
                                                                      epsilon
      8
                 0.522
                                 False
                                                                      epsilon
                                          94.274794
                                                            0.734561
      9
                 1.104
                                 False
                                          86.235038
                                                                      epsilon
                                                            0.738105
      10
                 2.197
                                 False
                                          82.538558
                                                            0.737964
                                                                      epsilon
      11
                 4.588
                                 False
                                                                      epsilon
                                          80.926339
                                                            0.739631
      12
                                 False
                 7.677
                                          80.216146
                                                            0.739354
                                                                      epsilon
      13
                 15.933
                                 False
                                          79.885937
                                                            0.738036
                                                                      epsilon
```