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Artificial Intelligence Diploma, PACE, University of Winnipeg

Course Name: Topics in Data Science

Assignment No-02(Lab)

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Submission Date: August 01, 2022

In [1]:

```
#Installing BlackBoxAuditing;The BlackBoxAuditing package has a few datasets preloaded and
#!pip install BlackBoxAuditing
```

In [2]:

```
#Installing Python,matplotlib and BlackBoxAuditing packages
%matplotlib inline
import matplotlib.pyplot as plt
import pylab

from sklearn.linear_model import LogisticRegression as LR

from BlackBoxAuditing.model_factories import SVM

from BlackBoxAuditing.data import load_from_file
from BlackBoxAuditing.model_factories.AbstractModelFactory import AbstractModelFactory
from BlackBoxAuditing.model_factories.AbstractModelVisitor import AbstractModelVisitor

import pandas as pd
import numpy as np
import random

import BlackBoxAuditing as BBA

import pickle
```

In [3]:

```
#Using a preloaded dataset
ricci_data = BBA.load_data("ricci")
```

In [4]:

```
#Display the type of the data
type(ricci_data)
```

Out[4]:

```
tuple
```

In [5]:

```
#Display the data from the dataset
ricci_data
```

Out[5]:

```
(['Position', 'Oral', 'Written', 'Race', 'Combine', 'Class'],
 [['Captain', 80.0, 95, 'W', 89.0, '1'],
  ['Captain', 82.38, 87, 'W', 85.152, '1'],
  ['Captain', 76.19, 84, 'W', 80.876, '1'],
  ['Captain', 76.19, 82, 'H', 79.676, '1'],
  ['Captain', 76.19, 82, 'W', 79.676, '1'],
  ['Captain', 84.29, 72, 'W', 76.916, '1'],
  ['Captain', 73.81, 77, 'W', 75.724, '1'],
  ['Captain', 73.33, 74, 'W', 73.732, '1'],
  ['Captain', 82.38, 64, 'W', 71.352, '1'],
  ['Captain', 78.57, 64, 'W', 69.828, '0'],
  ['Captain', 71.43, 68, 'W', 69.372, '0'],
  ['Captain', 59.05, 76, 'W', 69.22, '0'],
  ['Captain', 60.48, 75, 'H', 69.192, '0'],
  ['Captain', 57.14, 75, 'W', 67.856, '0'],
  ['Captain', 67.14, 65, 'H', 65.856, '0'],
  ['Captain', 55.24, 68, 'W', 62.896, '0'],
  ['Captain', 58.57, 65, 'H', 62.428, '0'],
  ['Captain', 48.57, 69, 'W', 60.828, '0'],
  ['Captain', 67.62, 56, 'B', 60.648, '0'],
  ['Captain', 57.14, 61, 'H', 59.456, '0'],
  ['Captain', 70.48, 50, 'B', 58.192, '0'],
  ['Captain', 53.81, 58, 'W', 56.324, '0'],
```

```
 ['Captain', 54.76, 49, 'B', 51.304, '0'],
 ['Lieutenant', 88.75, 91, 'W', 90.1, '1'],
 ['Lieutenant', 87.5, 87, 'W', 87.2, '1'],
 ['Lieutenant', 77.5, 91, 'W', 85.6, '1'],
 ['Lieutenant', 80.0, 87, 'W', 84.2, '1'],
 ['Lieutenant', 80.83, 84, 'W', 82.732, '1'],
 ['Lieutenant', 63.75, 95, 'W', 82.5, '1'],
 ['Lieutenant', 58.75, 89, 'W', 76.9, '1'],
 ['Lieutenant', 77.5, 76, 'B', 76.6, '1'],
 ['Lieutenant', 87.5, 66, 'W', 74.6, '1'],
 ['Lieutenant', 73.33, 71, 'W', 71.932, '1'],
 ['Lieutenant', 55.0, 82, 'H', 71.2, '1'],
 ['Lieutenant', 69.17, 72, 'H', 70.868, '1'],
 ['Lieutenant', 58.33, 79, 'W', 70.732, '1'],
 ['Lieutenant', 53.75, 82, 'H', 70.7, '1'],
 ['Lieutenant', 73.75, 68, 'W', 70.3, '1'],
 ['Lieutenant', 51.25, 80, 'W', 68.5, '0'],
 ['Lieutenant', 51.67, 79, 'W', 68.068, '0'],
 ['Lieutenant', 64.58, 69, 'W', 67.232, '0'],
 ['Lieutenant', 55.0, 73, 'W', 65.8, '0'],
 ['Lieutenant', 50.42, 75, 'W', 65.168, '0'],
 ['Lieutenant', 69.17, 60, 'B', 63.668, '0'],
 ['Lieutenant', 71.67, 57, 'W', 62.868, '0'],
 ['Lieutenant', 50.42, 71, 'H', 62.768, '0'],
 ['Lieutenant', 56.25, 66, 'W', 62.1, '0'],
 ['Lieutenant', 42.5, 73, 'H', 60.8, '0'],
 ['Lieutenant', 51.25, 67, 'H', 60.7, '0'],
 ['Lieutenant', 55.0, 64, 'B', 60.4, '0'],
 ['Lieutenant', 51.25, 66, 'B', 60.1, '0'],
 ['Lieutenant', 60.83, 58, 'B', 59.132, '0'],
 ['Lieutenant', 51.25, 62, 'W', 57.7, '0'],
 ['Lieutenant', 44.58, 66, 'W', 57.432, '0'],
 ['Lieutenant', 44.17, 66, 'H', 57.268, '0'],
 ['Lieutenant', 45.42, 65, 'W', 57.168, '0'],
 ['Lieutenant', 55.83, 58, 'B', 57.132, '0'],
 ['Lieutenant', 58.75, 55, 'B', 56.5, '0'],
 ['Lieutenant', 52.08, 56, 'B', 54.432, '0']],
[['Captain', 89.52, 95, 'W', 92.808, '1'],
 ['Captain', 88.57, 76, 'W', 81.028, '1'],
 ['Captain', 70.0, 84, 'H', 78.4, '1'],
 ['Captain', 73.81, 81, 'W', 78.124, '1'],
 ['Captain', 87.62, 69, 'W', 76.448, '1'],
 ['Captain', 80.0, 74, 'W', 76.4, '1'],
 ['Captain', 79.05, 74, 'H', 76.02, '1'],
 ['Captain', 76.67, 74, 'W', 75.068, '1'],
 ['Captain', 82.38, 70, 'B', 74.952, '1'],
 ['Captain', 70.0, 76, 'W', 73.6, '1'],
 ['Captain', 68.57, 74, 'B', 71.828, '1'],
 ['Captain', 56.67, 81, 'W', 71.268, '1'],
 ['Captain', 70.95, 70, 'B', 70.38, '1'],
 ['Captain', 62.38, 75, 'W', 69.952, '0'],
 ['Captain', 71.43, 68, 'W', 69.372, '0'],
 ['Captain', 52.38, 77, 'B', 67.152, '0'],
 ['Captain', 42.86, 67, 'H', 57.344, '0'],
 ['Captain', 60.0, 53, 'B', 55.8, '0'],
 ['Lieutenant', 85.0, 84, 'W', 84.4, '1'],
 ['Lieutenant', 73.75, 91, 'W', 84.1, '1'],
 ['Lieutenant', 73.33, 89, 'W', 82.732, '1'],
 ['Lieutenant', 68.33, 91, 'W', 81.932, '1'],
 ['Lieutenant', 69.58, 86, 'W', 79.432, '1'],
 ['Lieutenant', 73.75, 81, 'W', 78.1, '1'],
 ['Lieutenant', 61.25, 86, 'B', 76.1, '1'],
 ['Lieutenant', 80.42, 73, 'B', 75.968, '1'],
 ['Lieutenant', 74.17, 77, 'W', 75.868, '1'],
 ['Lieutenant', 63.33, 83, 'W', 75.132, '1'],
 ['Lieutenant', 65.83, 80, 'B', 74.332, '1'],
```

```
 ['Lieutenant', 78.33, 70, 'W', 73.332, '1'],
 ['Lieutenant', 70.83, 74, 'B', 72.732, '1'],
 ['Lieutenant', 66.67, 76, 'W', 72.268, '1'],
 ['Lieutenant', 92.08, 59, 'B', 72.232, '1'],
 ['Lieutenant', 72.5, 72, 'W', 72.2, '1'],
 ['Lieutenant', 65.83, 74, 'W', 70.732, '1'],
 ['Lieutenant', 77.5, 66, 'W', 70.6, '1'],
 ['Lieutenant', 71.67, 69, 'W', 70.068, '1'],
 ['Lieutenant', 64.58, 73, 'W', 69.632, '0'],
 ['Lieutenant', 70.83, 68, 'H', 69.132, '0'],
 ['Lieutenant', 73.75, 66, 'W', 69.1, '0'],
 ['Lieutenant', 58.75, 76, 'W', 69.1, '0'],
 ['Lieutenant', 62.5, 72, 'H', 68.2, '0'],
 ['Lieutenant', 70.83, 65, 'B', 67.332, '0'],
 ['Lieutenant', 79.17, 59, 'W', 67.068, '0'],
 ['Lieutenant', 56.25, 73, 'H', 66.3, '0'],
 ['Lieutenant', 66.25, 65, 'B', 65.5, '0'],
 ['Lieutenant', 57.5, 70, 'H', 65.0, '0'],
 ['Lieutenant', 51.67, 71, 'H', 63.268, '0'],
 ['Lieutenant', 56.67, 64, 'B', 61.068, '0'],
 ['Lieutenant', 56.25, 64, 'B', 60.9, '0'],
 ['Lieutenant', 49.58, 67, 'W', 60.032, '0'],
 ['Lieutenant', 60.0, 60, 'W', 60.0, '0'],
 ['Lieutenant', 46.25, 68, 'H', 59.3, '0'],
 ['Lieutenant', 57.92, 58, 'W', 57.968, '0'],
 ['Lieutenant', 54.58, 58, 'W', 56.632, '0'],
 ['Lieutenant', 40.83, 64, 'H', 54.732, '0'],
 ['Lieutenant', 48.33, 58, 'H', 54.132, '0'],
 ['Lieutenant', 52.92, 49, 'B', 50.568, '0'],
 ['Lieutenant', 45.83, 46, 'B', 45.932, '0']],
'Class',
[],
[str, float, int, str, float, str])
```

In [6]:

```
#Display total features of the dataset
len(ricci_data)
```

Out[6]:

```
6
```

In [7]:

```
# In the output-> Header->0,training data->1,testing data->2, response header->3, feature

for i in range(len(ricci_data)):
    print(i)
    print(type(ricci_data[0]))
```

```
0
<class 'list'>
1
<class 'list'>
2
<class 'list'>
3
<class 'list'>
4
<class 'list'>
5
<class 'list'>
```

In [8]:

```
#Display of header
ricci_data[0]
```

Out[8]:

```
['Position', 'Oral', 'Written', 'Race', 'Combine', 'Class']
```

In [9]:

```
#Total Number of Rows
len(ricci_data[1])
```

Out[9]:

```
59
```

In [10]:

```
#Training data (display randomly)
ricci_data[1][:10]
```

Out[10]:

```
[['Captain', 80.0, 95, 'W', 89.0, '1'],
 ['Captain', 82.38, 87, 'W', 85.152, '1'],
 ['Captain', 76.19, 84, 'W', 80.876, '1'],
 ['Captain', 76.19, 82, 'H', 79.676, '1'],
 ['Captain', 76.19, 82, 'W', 79.676, '1'],
 ['Captain', 84.29, 72, 'W', 76.916, '1'],
 ['Captain', 73.81, 77, 'W', 75.724, '1'],
 ['Captain', 73.33, 74, 'W', 73.732, '1'],
 ['Captain', 82.38, 64, 'W', 71.352, '1'],
 ['Captain', 78.57, 64, 'W', 69.828, '0']]
```

In [11]:

```
#testing data
df = pd.DataFrame(ricci_data[2])
df.columns = ricci_data[0]
df.head()
```

Out[11]:

	Position	Oral	Written	Race	Combine	Class
0	Captain	89.52	95	W	92.808	1
1	Captain	88.57	76	W	81.028	1
2	Captain	70.00	84	H	78.400	1
3	Captain	73.81	81	W	78.124	1
4	Captain	87.62	69	W	76.448	1

In [12]:

```
#Organizing dataset by Race (testing dataset)
df.groupby('Race').count()
```

Out[12]:

	Position	Oral	Written	Combine	Class
Race					
B	16	16	16	16	16
H	11	11	11	11	11
W	32	32	32	32	32

In [13]:

```
#Organizing dataset by Position(testing dataset)
df.groupby('Position').count()
```

Out[13]:

	Oral	Written	Race	Combine	Class
Position					
Captain	18	18	18	18	18
Lieutenant	41	41	41	41	41

In [14]:

```
#Organizing dataset by Race and position(testing dataset)
df.groupby(['Position', 'Race']).count()
```

Out[14]:

Position	Race	Oral	Written	Combine	Class
Captain	B	5	5	5	5
	H	3	3	3	3
	W	10	10	10	10
Lieutenant	B	11	11	11	11
	H	8	8	8	8
	W	22	22	22	22

In [15]:

```
# test dataset (display selection 10 rows randomly)
ricci_data[2][:10]
```

Out[15]:

```
[['Captain', 89.52, 95, 'W', 92.808, '1'],
 ['Captain', 88.57, 76, 'W', 81.028, '1'],
 ['Captain', 70.0, 84, 'H', 78.4, '1'],
 ['Captain', 73.81, 81, 'W', 78.124, '1'],
 ['Captain', 87.62, 69, 'W', 76.448, '1'],
 ['Captain', 80.0, 74, 'W', 76.4, '1'],
 ['Captain', 79.05, 74, 'H', 76.02, '1'],
 ['Captain', 76.67, 74, 'W', 75.068, '1'],
 ['Captain', 82.38, 70, 'B', 74.952, '1'],
 ['Captain', 70.0, 76, 'W', 73.6, '1']]
```

In [16]:

```
# import warnings filter
from warnings import simplefilter
# ignore all future warnings
simplefilter(action='ignore', category=FutureWarning)
```

In [17]:

```
# We then train the auditor with a few simple lines of code.
# In this case, we are learning how the library works and do not have an existing model,
# but the library works with this possibility by providing a model factory from which we
# can select some plausible models. In this case we’ll select the SVM option, which
# itself relies on an import from sklearn, which we can see by looking at the
# course code of SVM.py in the model_factories submodule of BBA.
#We then train, which entails deciding on an output directory because the results
#of the audit are saved in a variety of formats.
#initialize the auditor and set parameters
auditor                              = BBA.Auditor()
auditor.ModelFactory                 = SVM #supervised learning model, classify slash regrassion
# call the auditor with the data
auditor(ricci_data, output_dir ="ricci-audit-output")
```

```
Training initial model. (12:24:20)
Calculating original model statistics on test data:
        Training Set:
                Conf-Matrix: {'1': {'1': 24}, '0': {'0': 35}}
                accuracy: 1.0
                BCR: 1.0
        Testing Set:
                Conf-Matrix {'1': {'1': 29, '0': 3}, '0': {'0': 23, '1': 4}}
                accuracy: 0.8813559322033898
                BCR: 0.8790509259259259
```

```
Auditing: 'Position' (1/5). (12:24:20)
Auditing: 'Oral' (2/5). (12:24:20)
Auditing: 'Written' (3/5). (12:24:21)
Auditing: 'Race' (4/5). (12:24:22)
Auditing: 'Combine' (5/5). (12:24:22)
Audit file dump set to False: Only mininal audit files have been saved.
Audit files dumped to: ricci-audit-output.

Ranking audit files by accuracy. (12:24:23)
        [('Combine', 0.423728813559322), ('Oral', 0.3728813559322034), ('Written', 0.37288
13559322034), ('Race', 0.15254237288135597), ('Position', 0.016949152542372836)] (12:24:2
3)
Ranking audit files by BCR. (12:24:23)
        [('Combine', 0.4513888888888895), ('Oral', 0.39583333333333337), ('Written', 0.39
583333333333337), ('Race', 0.140625), ('Position', 0.012731481481481481)] (12:24:23)
Audit Start Time: 2022-08-01 12:24:20.081655
Audit End Time: 2022-08-01 12:24:23.423689
Retrained Per Repair: False
Model Factory ID: 1659378260.081655
Model Type: DecisionTree
Non-standard Model Options: {}
Train Size: 59
Test Size: 59
Non-standard Ignored Features: []
Features: ['Position', 'Oral', 'Written', 'Race', 'Combine', 'Class']

Ranked Features by accuracy: [('Combine', 0.423728813559322), ('Oral', 0.372881355932203
4), ('Written', 0.3728813559322034), ('Race', 0.15254237288135597), ('Position', 0.0169491
52542372836)]
        Approx. Trend Groups: [['Position'], ['Oral'], ['Written'], ['Race'], ['Combine']]

Ranked Features by BCR: [('Combine', 0.4513888888888895), ('Oral', 0.39583333333333337),
('Written', 0.39583333333333337), ('Race', 0.140625), ('Position', 0.012731481481481481)]
        Approx. Trend Groups: [['Position'], ['Oral'], ['Written'], ['Race'], ['Combine']]

Summary file written to: ricci-audit-output/summary.txt
 (12:24:23)
```

Output Analysis:

-Based on the confusion matric, the accuracy level of training data is 1 and balance classification rate is 1.These two rates indicate the model can predict true positive and true negative correctly.

-Based on the confusion matric, the accuracy level of testing data is 0.8813559322033898 and balance classification rate is 0.8790509259259259, which is very close to 1. These two rates indicate the model can predict true positive and true negative rate almost correctly.

-Based on the output, combine feature has the most accuracy.

In [18]:

```
# We can load some of the audit data back into our Jupyter notebook to examine it there
acc_data = pd.read_csv("ricci-audit-output/accuracy.png.data")
print(acc_data)
```

	Repair Level	Position	Oral	Written	Race	Combine
0	0.0	0.881356	0.881356	0.881356	0.881356	0.881356
1	0.1	0.881356	0.915254	0.898305	0.898305	0.847458
2	0.2	0.881356	0.898305	0.864407	0.881356	0.813559
3	0.3	0.864407	0.847458	0.864407	0.847458	0.796610
4	0.4	0.881356	0.796610	0.813559	0.830508	0.779661
5	0.5	0.864407	0.796610	0.830508	0.796610	0.847458
6	0.6	0.864407	0.762712	0.762712	0.796610	0.796610

```
7            0.7  0.881356  0.694915  0.762712  0.796610  0.728814
8            0.8  0.864407  0.610169  0.677966  0.779661  0.542373
9            0.9  0.864407  0.610169  0.542373  0.779661  0.559322
10           1.0  0.864407  0.508475  0.508475  0.728814  0.457627
```

Repair Level Output Analysis:

The 'combine' feature influences accuracy most compared to the other features with the changing of repair level from 0 to 1. Accuracy is changes most in 'combine', 'written' and 'oral' features with the changing of repair level; race feature has a little influence in accuracy and position feature has minimum influence in the accuracy. Considering the accuracy level and the influence features, it can be said that model is fair enough.

In [19]:
```
# We can then look at influence — that is, how much the accuracy changes from not obscuri
def influence(df):
    return (df.iloc[0][1:] - df.iloc[-1][1:])

influence(acc_data)
```

Out[19]:
```
Position    0.016949
Oral        0.372881
Written     0.372881
Race        0.152542
Combine     0.423729
dtype: float64
```

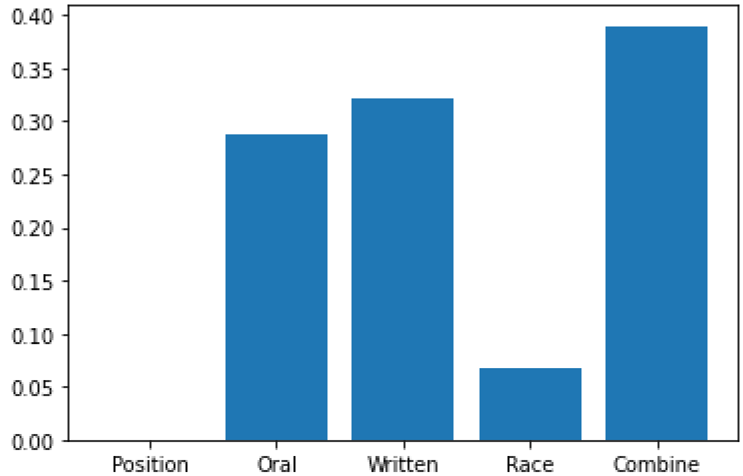
In [22]:
```
# And we can look at what happens if we want to see the influence if we imagine a repair 
def influence_partial_repair(df):
    return (df.iloc[0][1:] - df.iloc[5][1:])

influence_partial_repair(acc_data)
```

Out[22]:
```
Position    0.016949
Oral        0.084746
Written     0.050847
Race        0.084746
Combine     0.033898
dtype: float64
```

In [23]:
```
# you can visualize the difference per feature between a full repair and partial repair. I
import matplotlib
deltas = influence(acc_data) - influence_partial_repair(acc_data)
fig = plt.figure()
plt.bar(x = deltas.index, height = deltas.values)
fig
#plt.show()
```

Out[23]:



Graph Analysis:

Figure shows the difference per feature between a full repair and partial repair. We can see that, accuracy is changes most in combine, written and oral features; race feature has a little impact in accuracy and position feature has almost no influence in the accuracy.

Example-2

In [24]:

```
# Example 2
## first produce the data
## not covered in book, just background code needed to run example
SAMPLE_SIZE = 1000
credit_score = np.array(np.random.randn(SAMPLE_SIZE)) * 100 + 600
gender = np.array(random.choices(["female", "male", "non-binary", "prefer not to answer"],
                              weights = [0.48, 0.48, 0.02, 0.02],
                             k = SAMPLE_SIZE))
age = np.array(random.choices(range(18, 80), k = SAMPLE_SIZE))
length_employment = np.rint((age - 18) * np.random.uniform(size=SAMPLE_SIZE))
employee_score = credit_score * length_employment + random.choices(range(-1000, 1000), k =

hire = np.logical_or(np.logical_and(employee_score > 9000, np.logical_or(gender == "male",
                          employee_score > 9500).astype(float)
female = np.where(gender == 'female', 1, 0)
male = np.where(gender == 'male', 1, 0)
nonbinary = np.where(gender == 'nonbinary', 1, 0)
df = pd.DataFrame(
    {
        'credit_score'     : credit_score,
        'gender'           : gender,
        'age'              : age,
        'length_employment': length_employment,
        'employee_score'   : employee_score,
        'female'           : female,
        'male'             : male,
        'nonbinary'        : nonbinary,
        'hire'             : hire
    })
col_names = ['credit_score', 'age',
             'length_employment', 'employee_score',
            'female', 'male', 'nonbinary',
            'hire']
df.to_csv("synth_data.csv",
          index=False,
          columns=col_names)
```

In [25]:
```python
# Data Load
synthetic_data = load_from_file("synth_data.csv",
                                correct_types = np.repeat([float], [len(col_names)]),
                                response_header = 'hire',
                               train_percentage = 0.5)
```

In [26]:
```python
#Display of the dataset
synthetic_data
```

Out[26]:
```
([ 'credit_score',
  'age',
  'length_employment',
  'employee_score',
  'female',
  'male',
  'nonbinary',
  'hire'],
 [[535.6465504699339, 56.0, 14.0, 6859.051706579075, 1.0, 0.0, 0.0, 0.0],
  [533.9545909870775, 66.0, 2.0, 551.909181974155, 0.0, 1.0, 0.0, 0.0],
  [719.5152796881298, 56.0, 1.0, 1247.5152796881298, 0.0, 1.0, 0.0, 0.0],
  [483.54405301082636, 41.0, 5.0, 1958.7202650541317, 1.0, 0.0, 0.0, 0.0],
  [755.6006152076975, 58.0, 26.0, 19738.615995400134, 0.0, 1.0, 0.0, 1.0],
  [488.44903088526223, 51.0, 17.0, 7462.633525049458, 1.0, 0.0, 0.0, 0.0],
  [578.6324898376586, 24.0, 6.0, 3382.7949390259514, 1.0, 0.0, 0.0, 0.0],
  [477.2891952473656, 54.0, 22.0, 10942.362295442044, 0.0, 1.0, 0.0, 1.0],
  [412.5229060729513, 44.0, 14.0, 6748.320685020672, 1.0, 0.0, 0.0, 0.0],
  [800.7406456265434, 40.0, 1.0, 559.7406456265434, 0.0, 1.0, 0.0, 0.0],
  [760.0397274290641, 75.0, 7.0, 5949.278092003448, 1.0, 0.0, 0.0, 0.0],
  [640.9097933159724, 49.0, 10.0, 7178.097933159724, 0.0, 1.0, 0.0, 0.0],
  [725.8158537247571, 37.0, 9.0, 5820.342683522814, 0.0, 1.0, 0.0, 0.0],
  [740.3235697994274, 23.0, 5.0, 4409.617848997137, 0.0, 1.0, 0.0, 0.0],
  [634.2125505506831, 49.0, 22.0, 12959.676112115028, 0.0, 1.0, 0.0, 1.0],
  [569.4717150139976, 78.0, 19.0, 11691.962585265954, 0.0, 1.0, 0.0, 1.0],
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[733.3651013743472, 70.0, 11.0, 7415.016115117819, 1.0, 0.0, 0.0, 0.0],
[439.43275028299615, 51.0, 2.0, 1549.8655005659923, 0.0, 0.0, 0.0, 0.0],
[698.932544697939, 47.0, 10.0, 6885.32544697939, 0.0, 1.0, 0.0, 0.0],
[505.4597866112701, 52.0, 6.0, 4019.7587196676204, 0.0, 1.0, 0.0, 0.0],
[533.1562351655691, 66.0, 10.0, 5150.562351655692, 1.0, 0.0, 0.0, 0.0],
[574.6941517053144, 54.0, 31.0, 18238.51870286475, 0.0, 1.0, 0.0, 1.0],
[565.567616822096, 22.0, 1.0, 1470.5676168220962, 1.0, 0.0, 0.0, 0.0],
[752.0119477857968, 72.0, 8.0, 6011.095582286374, 0.0, 1.0, 0.0, 0.0],
[694.8507795141768, 54.0, 19.0, 13007.164810769358, 1.0, 0.0, 0.0, 1.0],
[606.6106216328999, 75.0, 19.0, 11510.601811025099, 0.0, 1.0, 0.0, 1.0],
[504.235415020509, 72.0, 13.0, 6471.060395266617, 1.0, 0.0, 0.0, 0.0],
[760.1111366209917, 61.0, 24.0, 18831.667278903802, 1.0, 0.0, 0.0, 1.0],
[578.2924148373556, 20.0, 0.0, 432.0, 0.0, 1.0, 0.0, 0.0],
[570.6717863105296, 35.0, 13.0, 8171.733222036884, 0.0, 1.0, 0.0, 0.0],
[706.0447869085623, 62.0, 28.0, 19602.254033439745, 1.0, 0.0, 0.0, 1.0],
[425.8866002188005, 65.0, 33.0, 13437.257807220416, 0.0, 1.0, 0.0, 1.0],
[669.9502048130857, 27.0, 4.0, 2847.800819252343, 0.0, 0.0, 0.0, 0.0],
[601.3325658979776, 35.0, 7.0, 4733.327961285843, 0.0, 1.0, 0.0, 0.0],
[514.6754306268161, 44.0, 9.0, 4588.078875641345, 0.0, 1.0, 0.0, 0.0],
[521.5810255319, 52.0, 14.0, 7544.134357446599, 0.0, 1.0, 0.0, 0.0],
[699.7582098966533, 41.0, 22.0, 16260.680617726372, 0.0, 1.0, 0.0, 1.0],
[501.33732198840045, 19.0, 1.0, 411.33732198840045, 0.0, 1.0, 0.0, 0.0],
[596.3085423076797, 71.0, 46.0, 27322.192946153264, 0.0, 0.0, 0.0, 1.0],
[761.4477464897802, 63.0, 5.0, 4018.238732448901, 1.0, 0.0, 0.0, 0.0],
[431.8242274375806, 28.0, 1.0, 1004.8242274375806, 0.0, 1.0, 0.0, 0.0],
[595.4916511223272, 29.0, 10.0, 5385.916511223272, 1.0, 0.0, 0.0, 0.0],
[702.3037683574549, 55.0, 11.0, 8342.341451932003, 1.0, 0.0, 0.0, 0.0],
[462.95632847324464, 74.0, 55.0, 24672.598066028455, 1.0, 0.0, 0.0, 1.0],
[389.96271943535373, 39.0, 11.0, 4455.589913788891, 0.0, 1.0, 0.0, 0.0],
[632.5447255524118, 31.0, 12.0, 7523.536706628942, 1.0, 0.0, 0.0, 0.0],
[697.4279716155739, 57.0, 20.0, 13804.559432311478, 0.0, 1.0, 0.0, 1.0],
[517.1102013454893, 63.0, 18.0, 9618.983624218807, 1.0, 0.0, 0.0, 1.0],
[731.0272046776091, 54.0, 25.0, 17681.680116940228, 1.0, 0.0, 0.0, 1.0],
[637.9176645262453, 60.0, 3.0, 1423.7529935787359, 0.0, 1.0, 0.0, 0.0],
[572.0697193317725, 72.0, 14.0, 7864.976070644815, 1.0, 0.0, 0.0, 0.0],
[586.0693426922894, 58.0, 23.0, 13190.594881922656, 0.0, 0.0, 0.0, 1.0],
[720.8206186924164, 26.0, 5.0, 2905.1030934620817, 1.0, 0.0, 0.0, 0.0],
[436.124153634992, 67.0, 4.0, 1340.4966145399687, 0.0, 1.0, 0.0, 0.0],
[611.1461005636703, 51.0, 17.0, 9574.483709582395, 1.0, 0.0, 0.0, 1.0],
[497.27654502777693, 53.0, 32.0, 15735.849440888862, 1.0, 0.0, 0.0, 1.0],
[634.1350843365447, 76.0, 16.0, 9367.161349384714, 0.0, 1.0, 0.0, 1.0],
[514.0567316101306, 52.0, 6.0, 3003.3403896607833, 0.0, 1.0, 0.0, 0.0],
[614.2616618235999, 37.0, 3.0, 1685.7849854707997, 0.0, 0.0, 0.0, 0.0],
[558.6690258819333, 66.0, 15.0, 8904.035388229, 0.0, 1.0, 0.0, 0.0],
[602.8750020296991, 69.0, 39.0, 23577.125079158264, 0.0, 1.0, 0.0, 1.0],
[433.37779475691315, 42.0, 21.0, 9518.933689895177, 1.0, 0.0, 0.0, 1.0],

```
 [493.1327335297119, 53.0, 19.0, 9881.521937064526, 0.0, 1.0, 0.0, 1.0],
 [496.3447744745758, 33.0, 3.0, 2080.034323423727, 1.0, 0.0, 0.0, 0.0],
 [628.19060848099, 63.0, 8.0, 4717.52486784792, 0.0, 0.0, 0.0, 0.0],
 [433.1184745792104, 25.0, 4.0, 1230.4738983168415, 1.0, 0.0, 0.0, 0.0],
 [551.3457308869808, 19.0, 1.0, 905.3457308869808, 0.0, 1.0, 0.0, 0.0],
 [609.905864532245, 54.0, 21.0, 13570.023155177145, 1.0, 0.0, 0.0, 1.0],
 [425.1372486166638, 25.0, 2.0, 52.274497233327565, 0.0, 1.0, 0.0, 0.0],
 [570.1168091771899, 33.0, 12.0, 6992.401710126279, 1.0, 0.0, 0.0, 0.0],
 [448.2732013171933, 21.0, 2.0, 461.5464026343866, 1.0, 0.0, 0.0, 0.0],
 [593.692017042393, 23.0, 1.0, -36.30798295760701, 1.0, 0.0, 0.0, 0.0],
 [760.5521761078614, 58.0, 15.0, 10983.282641617921, 1.0, 0.0, 0.0, 1.0],
 [606.1834021505665, 34.0, 1.0, 723.1834021505665, 0.0, 1.0, 0.0, 0.0],
 [447.1339022097226, 24.0, 5.0, 3108.669511048613, 0.0, 1.0, 0.0, 0.0],
 [605.408472116625, 46.0, 11.0, 6771.493193282875, 0.0, 1.0, 0.0, 0.0],
 [448.4578979408487, 77.0, 9.0, 4986.121081467638, 1.0, 0.0, 0.0, 0.0],
 [470.1256657318345, 61.0, 33.0, 16307.146969150537, 0.0, 1.0, 0.0, 1.0],
 [628.0367431248152, 45.0, 14.0, 8425.514403747413, 1.0, 0.0, 0.0, 0.0],
 [627.5513528141909, 78.0, 60.0, 37856.08116885145, 1.0, 0.0, 0.0, 1.0],
 [548.5210730830731, 28.0, 3.0, 2485.5632192492194, 0.0, 1.0, 0.0, 0.0],
 [564.9283780468205, 76.0, 42.0, 24504.991877966462, 1.0, 0.0, 0.0, 1.0],
 [620.4285323934064, 32.0, 13.0, 8292.570921114282, 0.0, 1.0, 0.0, 0.0],
 [593.7032710355985, 28.0, 1.0, 830.7032710355985, 0.0, 1.0, 0.0, 0.0],
 [537.2437967169147, 38.0, 6.0, 2671.4627803014882, 1.0, 0.0, 0.0, 0.0],
 [690.641039320342, 25.0, 7.0, 4244.4872752423935, 0.0, 1.0, 0.0, 0.0],
 [557.9506675128209, 44.0, 5.0, 2123.7533375641046, 0.0, 1.0, 0.0, 0.0],
 [668.9730160467738, 51.0, 6.0, 4674.838096280642, 1.0, 0.0, 0.0, 0.0],
 [505.20277974631944, 27.0, 2.0, 837.4055594926389, 1.0, 0.0, 0.0, 0.0],
 [585.029354651977, 19.0, 1.0, 988.029354651977, 0.0, 1.0, 0.0, 0.0],
 [723.2079323991172, 32.0, 6.0, 4020.247594394703, 1.0, 0.0, 0.0, 0.0],
 [500.08728193244696, 78.0, 34.0, 17782.967585703198, 0.0, 1.0, 0.0, 1.0],
 [698.1186983938488, 41.0, 8.0, 5715.949587150791, 0.0, 0.0, 0.0, 0.0]],
'hire',
[],
array([<class 'float'>, <class 'float'>, <class 'float'>, <class 'float'>,
       <class 'float'>, <class 'float'>, <class 'float'>, <class 'float'>],
      dtype=object))
```

In [27]:
```python
#Display type of the dataset
type(synthetic_data)
```

Out[27]:
```
tuple
```

In [30]:
```python
#Display header of the dataset
synthetic_data[0]
```

Out[30]:
```
['credit_score',
 'age',
 'length_employment',
 'employee_score',
 'female',
 'male',
 'nonbinary',
 'hire']
```

In [31]:
```python
#Display total rows of the dataset
len(synthetic_data[1])
```

Out[31]:
```
500
```

In [32]:
```python
# Defining train and test data
#But then another detour to build the "proprietary model" that will be opaque to BBA
```

```python
train_data          = pd.DataFrame(synthetic_data[1])
test_data           = pd.DataFrame(synthetic_data[2])
train_data.columns = test_data.columns = col_names
```

In [33]:
```python
#Display of Training datas
train_data.head()
```

Out[33]:

	credit_score	age	length_employment	employee_score	female	male	nonbinary	hire
0	535.646550	56.0	14.0	6859.051707	1.0	0.0	0.0	0.0
1	533.954591	66.0	2.0	551.909182	0.0	1.0	0.0	0.0
2	719.515280	56.0	1.0	1247.515280	0.0	1.0	0.0	0.0
3	483.544053	41.0	5.0	1958.720265	1.0	0.0	0.0	0.0
4	755.600615	58.0	26.0	19738.615995	0.0	1.0	0.0	1.0

In [34]:
```python
#Display of testing data
df = pd.DataFrame(synthetic_data[2])
df.columns = synthetic_data[0]
df.head()
```

Out[34]:

	credit_score	age	length_employment	employee_score	female	male	nonbinary	hire
0	625.487987	31.0	9.0	6221.391880	0.0	1.0	0.0	0.0
1	620.487375	50.0	19.0	11275.260117	1.0	0.0	0.0	1.0
2	458.345048	51.0	9.0	5059.105428	1.0	0.0	0.0	0.0
3	709.340407	19.0	0.0	-647.000000	0.0	1.0	0.0	0.0
4	739.076994	31.0	12.0	9049.923923	1.0	0.0	0.0	1.0

In [35]:
```python
#Organizing dataset by female','male','nonbinary
df.groupby(['female','male','nonbinary']).count()
```

Out[35]:

			credit_score	age	length_employment	employee_score	hire
female	**male**	**nonbinary**					
0.0	**0.0**	**0.0**	25	25	25	25	25
	1.0	**0.0**	232	232	232	232	232
1.0	**0.0**	**0.0**	243	243	243	243	243

In the test dataset, total female=243, male=232, nonbinary=25;

In [36]:
```python
#Organizing dataset by hire
df.groupby('hire').count()
```

Out[36]:

	credit_score	age	length_employment	employee_score	female	male	nonbinary
hire							
0.0	295	295	295	295	295	295	295
1.0	205	205	205	205	205	205	205

In the test dataset,among 500, 205 are hired and 295 are not hired.

In [37]:

```
#Organizing dataset by Position, female,male,nonbinary
df.groupby(['hire', 'female','male','nonbinary']).count()
```

Out[37]:

hire	female	male	nonbinary	credit_score	age	length_employment	employee_score
0.0	0.0	0.0	0.0	17	17	17	17
		1.0	0.0	131	131	131	131
	1.0	0.0	0.0	147	147	147	147
1.0	0.0	0.0	0.0	8	8	8	8
		1.0	0.0	101	101	101	101
	1.0	0.0	0.0	96	96	96	96

In the test dataset,among 500, -It is seen that,among 205 hired, f=96, m=101, nb=8; -Percentage of hiring(f=96/243=.40, m=101/232=.43, nb=8/25=.32); percentage of highring male seems compertably higher.

In [39]:

```
X = train_data.iloc[:, :-1] #dataset.iloc[:, :-1] means until the last column
Y = train_data.iloc[:, -1] #dataset.iloc[:, -1] it means the last column
```

About Regression analysis: Regression analysis is a reliable method of identifying which variables have impact on a topic of interest. The process of performing a regression allows you to confidently determine which factors matter most, which factors can be ignored, and how these factors influence each other. Example: Linear regression can be used to make simple predictions such as predicting exams scores based on the number of hours studied, the salary of an employee based on years of experience, and so on.

In [40]:

```
#Applying Linear regression (LR) model
#Linear regression finds the optimal linear relationship between independent variables and
#thus makes prediction accordingly.
lr = LR(max_iter=2000).fit(X, Y)
```

Linear Regression Scoring:

-What: This type of scoring is performed by implementing linear regression algorithm on the random sample of data. The process includes scoring techniques on variables that have linear dependencies. -How Calculate: In simple linear regression, we predict scores on one variable from the scores on a second variable. The variable we are predicting is called the criterion variable and is referred to as Y. The variable we are basing our predictions on is called the predictor variable and is referred to as X.

In [42]:

```
#Score using the using the scoring option on the given test data and labels.
X_test = test_data.iloc[:, :-1] #dataset.iloc[:, :-1] means until the last column
Y_test = test_data.iloc[:, -1] #dataset.iloc[:, -1] it means the last column
lr.score(X_test, Y_test)
```

Out[42]:

```
0.972
```

Comment on LR Scoring

-The best possible score is 1.0 and it can be negative (because the model can be arbitrarily worse). A constant model that always predicts the expected value of y , disregarding the input features, would get a score of 0.0. -The sign of a regression coefficient tells you whether there is a positive or negative correlation between each independent variable and the dependent variable. A positive coefficient indicates that as the value of the independent variable increases, the mean of the dependent variable also tends to increase.

-Here, the lr score is 0.972, which indicates good prediction by the model.

In [43]:

```
#picklening model object
#wb-Which means that you should always open a pickle file in binary mode: "wb" to write it
with open( 'lr.pickle', 'wb' ) as f:
    pickle.dump(lr, f ) # the method for saving the data out to the designated pickle file
```

In [44]:

```
#rb-Which means that you should always open a pickle file in binary mode and "rb" to read
with open( 'lr.pickle', 'rb' ) as f:
    lr2 = pickle.load(f)
```

In [45]:

```
# Return to on-topic example of auditing a black box model
#provide the name of the model factory so that the name can be printed in the logs.
#provide the class of the model factory so that an instance can be made upon request by th

class HirePredictorBuilder(AbstractModelFactory):
    def __init__(self, *args, **kwargs):
        AbstractModelFactory.__init__(self, *args, **kwargs)
        self.verbose_factory_name = "HirePredictor"
    def build(self, train_set):
        return HirePredictor()

class HirePredictor(AbstractModelVisitor):
    def __init__(self):
        with open( 'lr.pickle', 'rb' ) as f:
            self.lr = pickle.load(f)

    def test(self, test_set, test_name=""):
        return [[v[-1], self.lr.predict(np.expand_dims(np.array(v[:-1]), axis = 0))] for v
```

In [46]:

```
#Ingone warnings
import warnings
warnings.filterwarnings('ignore')
```

-Confusion Matrix:A confusion matrix is a table with the distribution of classifier performance on the data. Where: TP – true positive (the correctly predicted positive class outcome of the model), TN – true negative (the correctly predicted negative class outcome of the model), FP – false positive (the incorrectly predicted positive class outcome of the model), FN – false negative (the incorrectly predicted negative class outcome of the model). -Accuracy is a metric that summarizes the performance of a classification task by dividing the total correct prediction over the total prediction made by the model. It's the number of correctly predicted data points out of all the data points. This works on predicted classes seen on the confusion matrix, and not scores of a data point. Accuracy = (TP + TN) / (TP+FN+FP+TN) -Balanced accuracy is a metric we can use to assess the performance of a classification model. It is calculated as: Balanced accuracy = (Sensitivity + Specificity) / 2 We, have used these matrix to evaluate performance of the model.

In [47]:

```
#initialize the auditor and set parameters
auditor                            = BBA.Auditor()
#provide the name of the model factory
auditor.ModelFactory               = HirePredictorBuilder
# call the auditor with the data
#output_dir*: name of the directory that audit files will be dumped to.
auditor(synthetic_data, output_dir = "synthetic-audit-output")
```

```
Training initial model. (14:01:43)
Calculating original model statistics on test data:
        Training Set:
                Conf-Matrix: {0.0: {0.0: 308, 1.0: 6}, 1.0: {1.0: 181, 0.0: 5}}
                accuracy: 0.978
                BCR: 0.9770049996575577
        Testing Set:
                Conf-Matrix {0.0: {0.0: 286, 1.0: 9}, 1.0: {1.0: 200, 0.0: 5}}
                accuracy: 0.972
                BCR: 0.9725506407606449
Auditing: 'credit_score' (1/7). (14:01:43)
Auditing: 'age' (2/7). (14:01:44)
Auditing: 'length_employment' (3/7). (14:01:45)
Auditing: 'employee_score' (4/7). (14:01:47)
Auditing: 'female' (5/7). (14:01:48)
Auditing: 'male' (6/7). (14:01:49)
Auditing: 'nonbinary' (7/7). (14:01:50)
Audit file dump set to False: Only mininal audit files have been saved.
Audit files dumped to: synthetic-audit-output.

Ranking audit files by accuracy. (14:01:51)
        [('length_employment', 0.562), ('credit_score', 0.382), ('employee_score', 0.382),
('age', 0.21199999999999997), ('male', 0.026000000000000023), ('female', 0.010000000000000
009), ('nonbinary', 0.0)] (14:01:51)
Ranking audit files by BCR. (14:01:51)
        [('credit_score', 0.4725506407606449), ('length_employment', 0.4725506407606449),
('employee_score', 0.4725506407606449), ('age', 0.19603141794129808), ('male', 0.031707317
07317076), ('female', 0.015915667631252628), ('nonbinary', 0.0)] (14:01:51)
Audit Start Time: 2022-08-01 14:01:43.499501
Audit End Time: 2022-08-01 14:01:51.711327
Retrained Per Repair: False
Model Factory ID: 1659384103.4995012
Model Type: HirePredictor
Non-standard Model Options: {}
Train Size: 500
Test Size: 500
Non-standard Ignored Features: []
Features: ['credit_score', 'age', 'length_employment', 'employee_score', 'female', 'male',
'nonbinary', 'hire']

Ranked Features by accuracy: [('length_employment', 0.562), ('credit_score', 0.382), ('emp
loyee_score', 0.382), ('age', 0.21199999999999997), ('male', 0.026000000000000023), ('fema
le', 0.010000000000000009), ('nonbinary', 0.0)]
        Approx. Trend Groups: [['credit_score'], ['employee_score'], ['age'], ['length_emp
loyment'], ['female', 'male', 'nonbinary']]

Ranked Features by BCR: [('credit_score', 0.4725506407606449), ('length_employment', 0.472
5506407606449), ('employee_score', 0.4725506407606449), ('age', 0.19603141794129808), ('ma
le', 0.03170731707317076), ('female', 0.015915667631252628), ('nonbinary', 0.0)]
        Approx. Trend Groups: [['credit_score'], ['length_employment'], ['employee_scor
e'], ['age'], ['female', 'male', 'nonbinary']]

Summary file written to: synthetic-audit-output/summary.txt
 (14:01:52)
```

Output Analysis:

-Based on the confusion matric, the accuracy level of training data is 0.978 and balance classification rate is 0.9770049996575577, which is very close to 1. These two rates indicate the model can almost correctly predict true positive and true negative rate almost correctly.

-Based on the confusion matric, the accuracy level of testing data is 0.972 and balance classification rate is 0.9725506407606449, which is very close to 1. These two rates indicate the model can predict almost correctly true positive and true negative rate almost correctly.

-As the prediction accuracy based on the confusion matrix and balance classification rate is higher and close to 1, I think the model is fair enough to predict hiring accurately considering the features output.

-Ranked Features by accuracy: [('length_employment', 0.562), ('credit_score', 0.382), ('employee_score', 0.382), ('age', 0.21199999999999997), ('male', 0.026000000000000023), ('female', 0.010000000000000009), ('nonbinary', 0.0)]

-Ranked Features by BCR: [('credit_score', 0.4725506407606449), ('length_employment', 0.4725506407606449), ('employee_score', 0.4725506407606449), ('age', 0.19603141794129808), ('male', 0.03170731707317076), ('female', 0.015915667631252628), ('nonbinary', 0.0)]

-A little differectce is showing in ranking features by accuracy and BCR. According to the confusion matrix accuracy 'length_employment' has the highest accuracy and 'credit_score' has the highest accuracy according to the BCR.

In [52]:

```
# We can load some of the audit data back into our Jupyter notebook to examine it there
acc_data = pd.read_csv("synthetic-audit-output/accuracy.png.data")
print(acc_data)
```

```
    Repair Level  credit_score    age  length_employment  employee_score  \
0            0.0         0.972  0.972              0.972           0.972
1            0.1         0.960  0.968              0.934           0.926
2            0.2         0.934  0.962              0.832           0.902
3            0.3         0.922  0.942              0.712           0.876
4            0.4         0.882  0.928              0.532           0.828
5            0.5         0.778  0.888              0.412           0.794
6            0.6         0.630  0.846              0.410           0.738
7            0.7         0.590  0.822              0.410           0.712
8            0.8         0.590  0.800              0.410           0.692
9            0.9         0.590  0.766              0.408           0.622
10           1.0         0.590  0.760              0.410           0.590

    female   male  nonbinary
0    0.972  0.972      0.972
1    0.968  0.972      0.972
2    0.970  0.972      0.972
3    0.970  0.972      0.972
4    0.972  0.968      0.972
5    0.970  0.966      0.972
6    0.968  0.960      0.972
7    0.968  0.956      0.972
8    0.964  0.950      0.972
9    0.962  0.948      0.972
10   0.962  0.946      0.972
```

Repair Level Output Analysis:

-The 'length_employment' feature influences accuracy most compared to the other features with the changing of repair level from 0 to 1; the accuracy changes most at repair level 0.5 for 'length_employment' feature.

-Accuracy is changes most in 'length_employment', 'credit_score', 'employee_score' and 'age' features with the changing of repair level.

-'male','female'and 'nonbinary' features have almost no influence in the accuracy for changing level of repair; that means, the model is not biased by the influence of gender.

In [53]:

```
# We can then look at influence — that is, how much the accuracy changes from not obscuri
#all to completely obscuring it.
def influence(df):
    return (df.iloc[0][1:] - df.iloc[-1][1:])

influence(acc_data)
```

Out[53]:

```
credit_score         0.382
age                  0.212
length_employment    0.562
employee_score       0.382
female               0.010
male                 0.026
nonbinary            0.000
dtype: float64
```

In [54]:

```
# And we can look at what happens if we want to see the influence if we imagine a repair
def influence_partial_repair(df):
    return (df.iloc[0][1:] - df.iloc[5][1:])

influence_partial_repair(acc_data)
```

Out[54]:

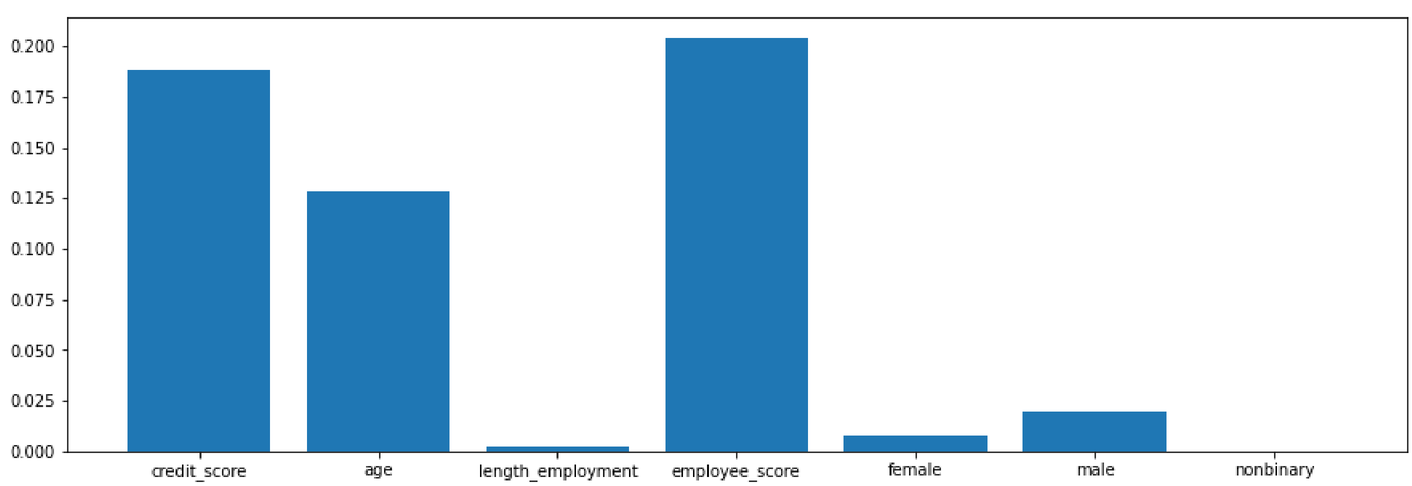
```
credit_score         0.194
age                  0.084
length_employment    0.560
employee_score       0.178
female               0.002
male                 0.006
nonbinary            0.000
dtype: float64
```

NOte: The change in influence of a feature when going from a full obscuration of that feature to a partial, where positive values indicate that the feature shows more influence with a full obscuration, which would be the expected result in that it indicates a greater change in accuracy when a feature is fully obscured rather than partially obscured.

In [55]:

```
# you can visualize the difference per feature between a full repair and partial repair.
#Note this merely contains redundant information compared to the accuracy plot.
import matplotlib
deltas = influence(acc_data) - influence_partial_repair(acc_data)
fig= plt.figure(figsize=(15, 5))
#fig = plt.figure()
plt.bar(x = deltas.index, height = deltas.values)
fig
```

Out[55]:



Analysis of the Graph and influence_partial_repair:

From the graph and influence_partial_repair output it has been seen that, the 'length_employment' has maximum impact to accuracy while repair it as partial(0.5) levelinsted of fully obscured. The employee_score, credit_score, age indicate change in accuracy when these features are fully obscured rather than partially obscured. The 'male','female'and 'nonbinary' features have almost no influence in the accuracy for changing level of repair.

Audit Report of synthetic_data (Example-2)

Matrix Outcome and Calculations:

Training Data Set Output:

Conf-Matrix: {0.0: {0.0: 308, 1.0: 6}, 1.0: {1.0: 181, 0.0: 5}}
Accuracy: 0.978
BCR: 0.9770049996575577

Conf-Matrix Calculation of training dataset:
Training dataset-> (hire-1 among 186, TP=181, TN=5), (not-hire-0, among 314, TN=308, FP=6)

Accuracy for training dataset = (181+308)/ (186+314) = 0.978

Balanced classification rate for training dataset:

Predicted-Training Dataset			
Actual	Hire-1	Not-hire-0	Total
1	181	5	186
0	308	6	314

- **Sensitivity**: The “true positive rate” = 181 / 186 = .97311
- **Specificity**: The “true negative rate” = 308 / 314 = 0.9808
- Balanced accuracy = (Sensitivity + Specificity) / 2=0.977

Testing DataSet Output:

Conf-Matrix {0.0: {0.0: 286, 1.0: 9}, 1.0: {1.0: 200, 0.0: 5}}
Accuracy: 0.972
BCR: 0.9725506407606449

Conf-Matrix Calculation of testing dataset:
Testing dataset-> (hire-1 among 205, TP=200, TN=5), (not-hire-0, among 295, TN=286, FP=9)

Accuracy for Testing dataset= (200+286)/(205+295)= 0.972

Balanced classification rate for testing dataset:

Predicted-Testing Dataset			
Actual	Hire-1	Not-hire-0	Total
1	200	5	205
0	286	9	295

- **Sensitivity**: The “true positive rate” = 200 / 205 = 0.97560
- **Specificity**: The “true negative rate” = 286 / 295= 0.96949
- Balanced accuracy = (Sensitivity + Specificity) / 2=.97254

Matrix Outcome and Graph Analysis:

-Based on the confusion matric, the accuracy level of training data is 0.978 and balance classification rate is 0.9770049996575577, which is very close to 1. These two rates indicate the model can almost correctly predict true positive and true negative rate almost correctly.

-Based on the confusion matric, the accuracy level of testing data is 0.972 and balance classification rate is 0.9725506407606449, which is very close to 1. These two rates indicate the model can predict almost correctly true positive and true negative rate almost correctly.

-Ranked Features by accuracy: [('length_employment', 0.562), ('credit_score', 0.382), ('employee_score', 0.382), ('age', 0.21199999999999997), ('male', 0.026000000000000023), ('female', 0.010000000000000009), ('nonbinary', 0.0)]

-Ranked Features by BCR: [('credit_score', 0.4725506407606449), ('length_employment', 0.4725506407606449), ('employee_score', 0.4725506407606449), ('age', 0.19603141794129808), ('male', 0.03170731707317076), ('female', 0.015915667631252628), ('nonbinary', 0.0)]

-A little differectce is showing in ranking features by accuracy and BCR. According to the confusion matrix accuracy 'length_employment' has the highest accuracy and 'credit_score' has the highest accuracy according to the BCR. Then 'employee_score', 'age', 'male', 'female' and 'nonbinary' features scores come consequently.

Repair Level Output Table and Graph Analysis:

	Repair Level	credit_score	age	length_employment	employee_score	female	male	nonbinary
0	0.0	0.972	0.972	0.972	0.972	0.972	0.972	0.972
1	0.1	0.960	0.968	0.934	0.926	0.968	0.972	0.972
2	0.2	0.934	0.962	0.832	0.902	0.970	0.972	0.972
3	0.3	0.922	0.942	0.712	0.876	0.970	0.972	0.972
4	0.4	0.882	0.928	0.532	0.828	0.972	0.968	0.972
5	0.5	0.778	0.888	0.412	0.794	0.970	0.966	0.972
6	0.6	0.630	0.846	0.410	0.738	0.968	0.960	0.972
7	0.7	0.590	0.822	0.410	0.712	0.968	0.956	0.972
8	0.8	0.590	0.800	0.410	0.692	0.964	0.950	0.972
9	0.9	0.590	0.766	0.408	0.622	0.962	0.948	0.972
10	1.0	0.590	0.760	0.410	0.590	0.962	0.946	0.972

Fig1: Repair Level Output Table

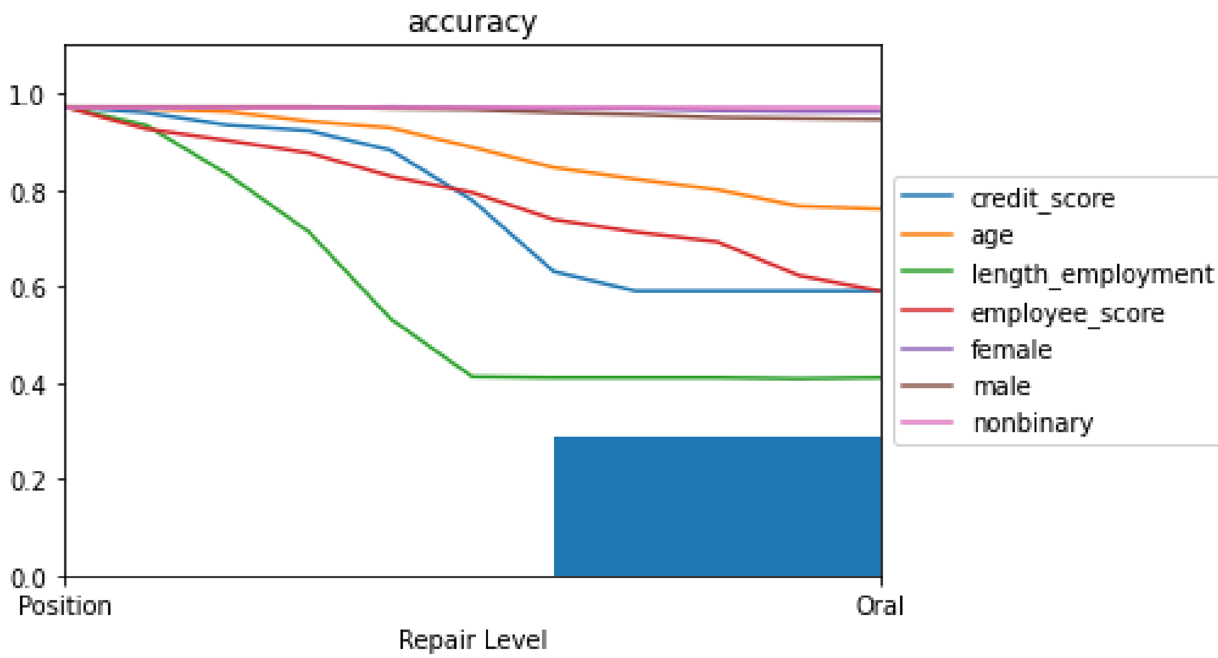


Fig2: Influence of Accuracy with Change of Repair Level

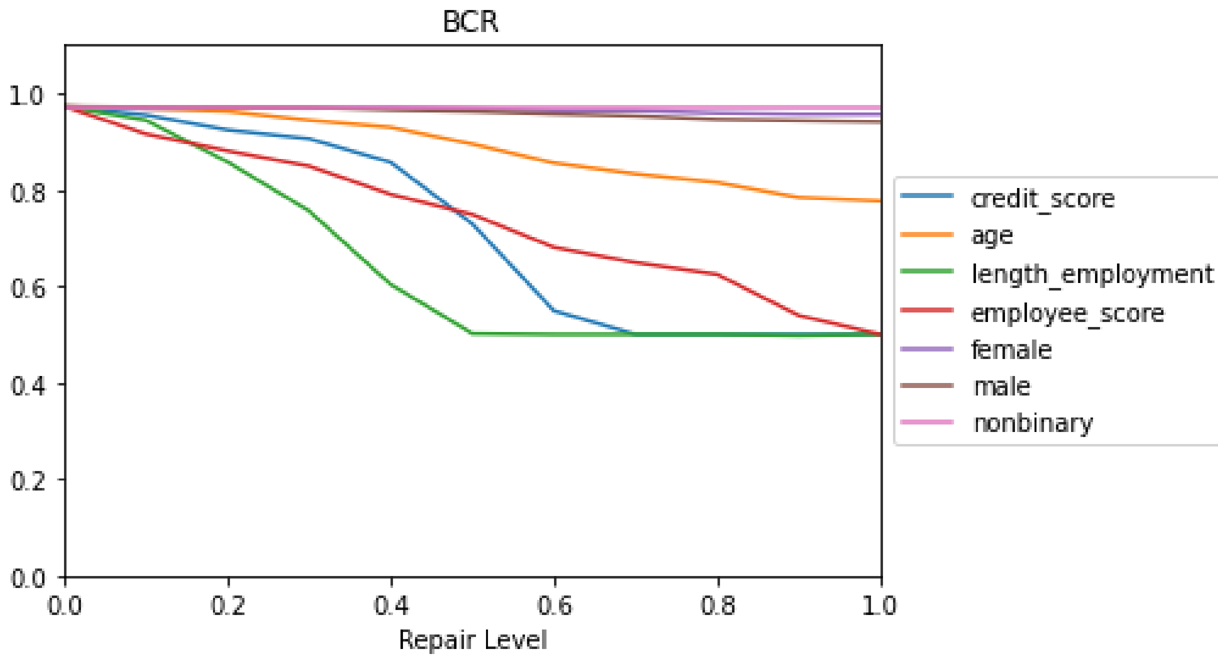


Fig3: Influence of BCR with Change of Repair Level

From the Fig-1,2,3 It has been seen that:

-The 'length_employment' feature influences accuracy most compared to the other features with the changing of repair level from 0 to 1; the accuracy changes most at repair level 0.5 for 'length_employment' feature.

-Accuracy is changes most in 'length_employment', 'credit_score', 'employee_score' and 'age' features with the changing of repair level.

-'male','female'and 'nonbinary' features have almost no influence in the accuracy for changing level of repair.

Conclusion: After analysis of the table and graphs, it has been seen that hiring is greatly influenced by the 'length_employment', 'credit_score', 'employee_score' and 'age' and least influenced by 'male','female'and 'nonbinary' features. That means, the model is not biased by the influence of gender, it predict hiring based on the required features. Besides, prediction accuracy based on the confusion matrix and balance classification rate is also higher and close to 1. Overall, I think the model is fair enough to predict hiring correctly.