Raport

May 27, 2022

1 Przewidywanie zwycięzcy rundy w grze Counter Strike: Global Offensive

1.1 Zmiany 26.05

- dodano rozdział "Optymalizacja hiperparametrów"
- dodano dodatkowe wykresy przedstawiające uzyskane wyniki w zależności od liczby epok

1.2 Dane

Zbiór danych składa się ze snapshotów rund z około 700 meczów z profesjonalnych turniejów rozgrywanych w 2019 i 2020 roku.

Snapshoty - czyli zestawienie pewnych stanów kluczowych elementów rozgrywki - były rejestrowane podczas gry co 20 sekund aż do rozstrzygnięcia danej rundy. Łączna liczba zapisanych snapshotów wynosi 122411. Część tych rekordów będzie traktowana jako zbiór danych uczących, a pozostała część jako część danych testów. Każdy rekord traktowany jest jako pojedynczy, niezależny element do analizy danych.

1.3 Czym jest klasyfikator MLP?

Perceptron wielowarstwowy (MLP) to model sztucznej sieci neuronowej ze sprzężeniem do przodu, który odwzorowuje zestawy danych wejściowych na zestaw odpowiednich danych wyjściowych.

MLP składa się z wielu warstw, a każda warstwa jest w pełni połączona z następną. Węzły warstw to neurony z nieliniowymi funkcjami aktywacji, z wyjątkiem węzłów warstwy wejściowej. Pomiędzy warstwą wejściową a wyjściową może znajdować się jedna lub więcej nieliniowych warstw ukrytych.

1.4 Import bibliotek i danych

[1]:

```
import numpy as np
import pandas as pd
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import RobustScaler
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.neural_network import MLPClassifier
from sklearn.linear_model import LogisticRegression
from matplotlib import pyplot as plt
import seaborn as sns
```

[2]:

```
df = pd.read_csv('Data/csgo_round_snapshots.csv')
```

[3]:

```
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', None)
```

[4]:

```
df.head()
```

[4]:

```
   time_left  ct_score  t_score       map  bomb_planted  ct_health  t_health  \
0     175.00       0.0      0.0  de_dust2         False      500.0     500.0
1     156.03       0.0      0.0  de_dust2         False      500.0     500.0
2      96.03       0.0      0.0  de_dust2         False      391.0     400.0
3      76.03       0.0      0.0  de_dust2         False      391.0     400.0
4     174.97       1.0      0.0  de_dust2         False      500.0     500.0

   ct_armor  t_armor  ct_money  t_money  ct_helmets  t_helmets  \
0       0.0      0.0    4000.0   4000.0         0.0        0.0
1     400.0    300.0     600.0    650.0         0.0        0.0
2     294.0    200.0     750.0    500.0         0.0        0.0
3     294.0    200.0     750.0    500.0         0.0        0.0
4     192.0      0.0   18350.0  10750.0         0.0        0.0

   ct_defuse_kits  ct_players_alive  t_players_alive  ct_weapon_ak47  \
0             0.0               5.0              5.0             0.0
1             1.0               5.0              5.0             0.0
2             1.0               4.0              4.0             0.0
3             1.0               4.0              4.0             0.0
4             1.0               5.0              5.0             0.0

   t_weapon_ak47  ct_weapon_aug  t_weapon_aug  ct_weapon_awp  t_weapon_awp  \
0            0.0            0.0           0.0            0.0           0.0
1            0.0            0.0           0.0            0.0           0.0
2            0.0            0.0           0.0            0.0           0.0
3            0.0            0.0           0.0            0.0           0.0
4            0.0            0.0           0.0            0.0           0.0

   ct_weapon_bizon  t_weapon_bizon  ct_weapon_cz75auto  t_weapon_cz75auto  \
0              0.0             0.0                 0.0                0.0
1              0.0             0.0                 0.0                0.0
2              0.0             0.0                 0.0                0.0
3              0.0             0.0                 0.0                0.0
4              0.0             0.0                 0.0                0.0

   ct_weapon_elite  t_weapon_elite  ct_weapon_famas  t_weapon_famas  \
0              0.0             0.0              0.0             0.0
1              0.0             0.0              0.0             0.0
2              0.0             0.0              0.0             0.0
3              0.0             0.0              0.0             0.0
4              0.0             0.0              0.0             0.0

   ct_weapon_g3sg1  t_weapon_g3sg1  ct_weapon_galilar  t_weapon_galilar  \
0              0.0             0.0                0.0               0.0
1              0.0             0.0                0.0               0.0
2              0.0             0.0                0.0               0.0
3              0.0             0.0                0.0               0.0
4              0.0             0.0                0.0               0.0

   ct_weapon_glock  t_weapon_glock  ct_weapon_m249  t_weapon_m249  \
0              0.0             5.0             0.0            0.0
1              0.0             5.0             0.0            0.0
2              0.0             4.0             0.0            0.0
3              0.0             3.0             0.0            0.0
4              0.0             5.0             0.0            0.0

   ct_weapon_m4a1s  t_weapon_m4a1s  ct_weapon_m4a4  t_weapon_m4a4  \
0              0.0             0.0             0.0            0.0
1              0.0             0.0             0.0            0.0
2              0.0             0.0             0.0            0.0
3              0.0             0.0             0.0            0.0
4              0.0             0.0             0.0            0.0

   ct_weapon_mac10  t_weapon_mac10  ct_weapon_mag7  t_weapon_mag7  \
0              0.0             0.0             0.0            0.0
1              0.0             0.0             0.0            0.0
2              0.0             0.0             0.0            0.0
3              0.0             0.0             0.0            0.0
4              0.0             0.0             0.0            0.0

   ct_weapon_mp5sd  t_weapon_mp5sd  ct_weapon_mp7  t_weapon_mp7  \
0              0.0             0.0            0.0           0.0
1              0.0             0.0            0.0           0.0
2              0.0             0.0            0.0           0.0
3              0.0             0.0            0.0           0.0
4              0.0             0.0            0.0           0.0
```

```
   ct_weapon_mp9  t_weapon_mp9  ct_weapon_negev  t_weapon_negev  \
0            0.0           0.0              0.0             0.0   
1            0.0           0.0              0.0             0.0   
2            0.0           0.0              0.0             0.0   
3            0.0           0.0              0.0             0.0   
4            0.0           0.0              0.0             0.0   

   ct_weapon_nova  t_weapon_nova  ct_weapon_p90  t_weapon_p90  \
0             0.0            0.0            0.0           0.0   
1             0.0            0.0            0.0           0.0   
2             0.0            0.0            0.0           0.0   
3             0.0            0.0            0.0           0.0   
4             0.0            0.0            0.0           0.0   

   ct_weapon_r8revolver  t_weapon_r8revolver  ct_weapon_sawedoff  \
0                   0.0                  0.0                 0.0   
1                   0.0                  0.0                 0.0   
2                   0.0                  0.0                 0.0   
3                   0.0                  0.0                 0.0   
4                   0.0                  0.0                 0.0   

   t_weapon_sawedoff  ct_weapon_scar20  t_weapon_scar20  ct_weapon_sg553  \
0                0.0               0.0              0.0              0.0   
1                0.0               0.0              0.0              0.0   
2                0.0               0.0              0.0              0.0   
3                0.0               0.0              0.0              0.0   
4                0.0               0.0              0.0              0.0   

   t_weapon_sg553  ct_weapon_ssg08  t_weapon_ssg08  ct_weapon_ump45  \
0             0.0              0.0             0.0              0.0   
1             0.0              0.0             0.0              0.0   
2             0.0              0.0             0.0              0.0   
3             0.0              0.0             0.0              0.0   
4             0.0              0.0             0.0              0.0   

   t_weapon_ump45  ct_weapon_xm1014  t_weapon_xm1014  ct_weapon_deagle  \
0             0.0               0.0              0.0               0.0   
1             0.0               0.0              0.0               0.0   
2             0.0               0.0              0.0               0.0   
3             0.0               0.0              0.0               0.0   
4             0.0               0.0              0.0               0.0   

   t_weapon_deagle  ct_weapon_fiveseven  t_weapon_fiveseven  ct_weapon_usps  \
0              0.0                  0.0                 0.0             4.0   
1              0.0                  0.0                 0.0             4.0   
2              0.0                  0.0                 0.0             4.0   
```

```
3              0.0                  0.0                  0.0             4.0
4              0.0                  0.0                  0.0             4.0

   t_weapon_usps  ct_weapon_p250  t_weapon_p250  ct_weapon_p2000  \
0            0.0             0.0            0.0              1.0
1            0.0             0.0            0.0              1.0
2            0.0             0.0            0.0              0.0
3            0.0             0.0            0.0              0.0
4            0.0             0.0            0.0              1.0

   t_weapon_p2000  ct_weapon_tec9  t_weapon_tec9  ct_grenade_hegrenade  \
0             0.0             0.0            0.0                   0.0
1             0.0             0.0            0.0                   0.0
2             0.0             0.0            0.0                   0.0
3             1.0             0.0            0.0                   0.0
4             0.0             0.0            0.0                   0.0

   t_grenade_hegrenade  ct_grenade_flashbang  t_grenade_flashbang  \
0                  0.0                   0.0                  0.0
1                  0.0                   0.0                  0.0
2                  0.0                   0.0                  0.0
3                  0.0                   0.0                  0.0
4                  0.0                   0.0                  0.0

   ct_grenade_smokegrenade  t_grenade_smokegrenade  \
0                      0.0                     0.0
1                      0.0                     2.0
2                      0.0                     2.0
3                      0.0                     0.0
4                      0.0                     0.0

   ct_grenade_incendiarygrenade  t_grenade_incendiarygrenade  \
0                           0.0                          0.0
1                           0.0                          0.0
2                           0.0                          0.0
3                           0.0                          0.0
4                           0.0                          0.0

   ct_grenade_molotovgrenade  t_grenade_molotovgrenade  \
0                        0.0                       0.0
1                        0.0                       0.0
2                        0.0                       0.0
3                        0.0                       0.0
4                        0.0                       0.0

   ct_grenade_decoygrenade  t_grenade_decoygrenade round_winner
0                      0.0                     0.0           CT
```

```
1                      0.0                     0.0            CT
2                      0.0                     0.0            CT
3                      0.0                     0.0            CT
4                      0.0                     0.0            CT
```

[5]:
```
df.isnull().sum().sum()
```

[5]:
```
0
```

[6]:
```
df.shape
```

[6]:
```
(122410, 97)
```

1.5 Przeprocesowanie danych

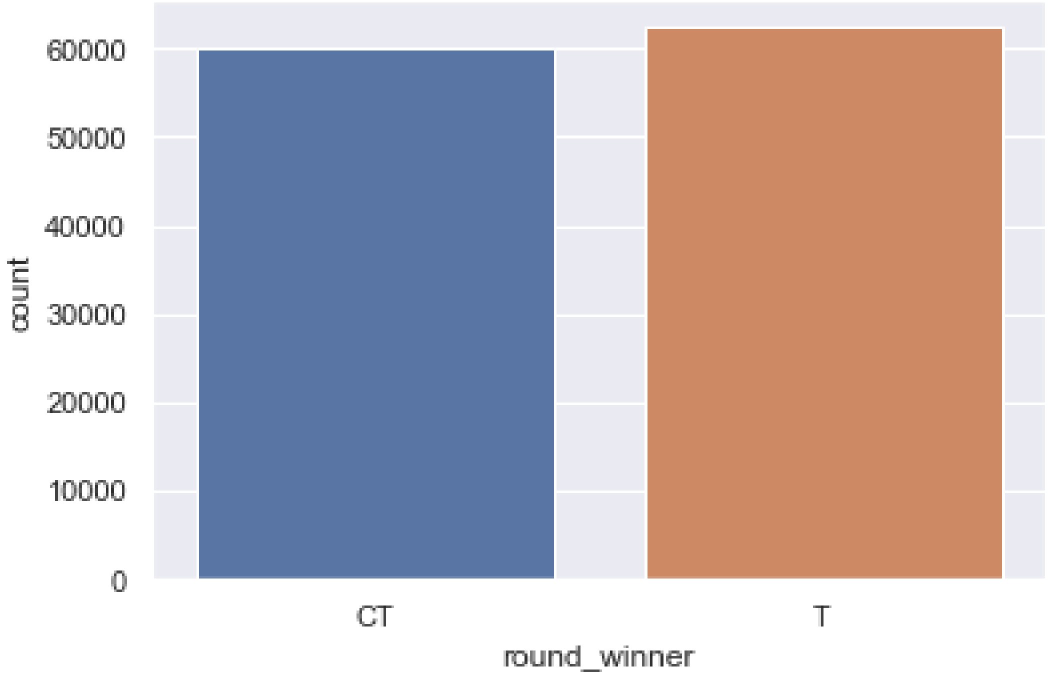
W pierwszej koleności sprawdźmy liczność klas.

[7]:
```
df['round_winner'].value_counts()
```

[7]:
```
T      62406
CT     60004
Name: round_winner, dtype: int64
```

[8]:
```
sns.set_theme(style="darkgrid")
sns.countplot(x='round_winner', data=df)
```

[8]:
```
<AxesSubplot:xlabel='round_winner', ylabel='count'>
```



Następnie przekonwertujemy wszystkie kolumny na wartości liczbowe.

```
[9]: col = df.drop(df.select_dtypes(np.number), axis = 1).columns
     col
```

```
[9]: Index(['map', 'bomb_planted', 'round_winner'], dtype='object')
```

```
[10]: lbl = LabelEncoder()
      for value in col:
          df[value] = lbl.fit_transform(df[value])
```

```
[11]: df['bomb_planted'] = df['bomb_planted'].astype(np.int16)
```

```
[12]: cols = [f for f in df.columns if f not in ['round_winner']]
```

Dodatkowo każda wartość zostanie znormalizowana.

```
[13]: scaler = RobustScaler()

      for value in cols:
          scaler = RobustScaler()
          df[value] = scaler.fit_transform(df[[value]])
```

Na koniec podzielimy dane na wektor danych oraz wektor wyników.

```
[14]: x = df.drop(['round_winner'], axis = 1)
      y = df['round_winner']
```

```
[15]: len(cols)
```

```
[15]: 96
```

Finalnie każdy rekord zawiera 96 atrybutów, które prezentują się w sposób przedstawiony poniżej.

```
[16]: x.head()
```

```
[16]:    time_left  ct_score   t_score       map  bomb_planted  ct_health  t_health  \
      0   0.715105 -0.857143 -0.857143 -0.666667           0.0   0.000000  0.000000
      1   0.545726 -0.857143 -0.857143 -0.666667           0.0   0.000000  0.000000
      2   0.010000 -0.857143 -0.857143 -0.666667           0.0  -0.726667 -0.561798
      3  -0.168575 -0.857143 -0.857143 -0.666667           0.0  -0.726667 -0.561798
      4   0.714837 -0.714286 -0.857143 -0.666667           0.0   0.000000  0.000000

         ct_armor   t_armor  ct_money   t_money  ct_helmets  t_helmets  \
      0 -1.291096 -1.136054 -0.112782 -0.191489        -0.5       -0.6
      1  0.078767 -0.115646 -0.368421 -0.395137        -0.5       -0.6
```

```
2 -0.284247 -0.455782 -0.357143 -0.404255        -0.5       -0.6
3 -0.284247 -0.455782 -0.357143 -0.404255        -0.5       -0.6
4 -0.633562 -1.136054  0.966165  0.218845        -0.5       -0.6

   ct_defuse_kits  ct_players_alive  t_players_alive  ct_weapon_ak47  \
0       -0.333333               0.0              0.0             0.0
1        0.000000               0.0              0.0             0.0
2        0.000000              -1.0             -1.0             0.0
3        0.000000              -1.0             -1.0             0.0
4        0.000000               0.0              0.0             0.0

   t_weapon_ak47  ct_weapon_aug  t_weapon_aug  ct_weapon_awp  t_weapon_awp  \
0           -0.5            0.0           0.0            0.0           0.0
1           -0.5            0.0           0.0            0.0           0.0
2           -0.5            0.0           0.0            0.0           0.0
3           -0.5            0.0           0.0            0.0           0.0
4           -0.5            0.0           0.0            0.0           0.0

   ct_weapon_bizon  t_weapon_bizon  ct_weapon_cz75auto  t_weapon_cz75auto  \
0              0.0             0.0                 0.0                0.0
1              0.0             0.0                 0.0                0.0
2              0.0             0.0                 0.0                0.0
3              0.0             0.0                 0.0                0.0
4              0.0             0.0                 0.0                0.0

   ct_weapon_elite  t_weapon_elite  ct_weapon_famas  t_weapon_famas  \
0              0.0             0.0              0.0             0.0
1              0.0             0.0              0.0             0.0
2              0.0             0.0              0.0             0.0
3              0.0             0.0              0.0             0.0
4              0.0             0.0              0.0             0.0

   ct_weapon_g3sg1  t_weapon_g3sg1  ct_weapon_galilar  t_weapon_galilar  \
0              0.0             0.0                0.0               0.0
1              0.0             0.0                0.0               0.0
2              0.0             0.0                0.0               0.0
3              0.0             0.0                0.0               0.0
4              0.0             0.0                0.0               0.0

   ct_weapon_glock  t_weapon_glock  ct_weapon_m249  t_weapon_m249  \
0              0.0        0.333333             0.0            0.0
1              0.0        0.333333             0.0            0.0
2              0.0        0.000000             0.0            0.0
3              0.0       -0.333333             0.0            0.0
4              0.0        0.333333             0.0            0.0

   ct_weapon_m4a1s  t_weapon_m4a1s  ct_weapon_m4a4  t_weapon_m4a4  \
0              0.0             0.0            -0.5            0.0
1              0.0             0.0            -0.5            0.0
2              0.0             0.0            -0.5            0.0
3              0.0             0.0            -0.5            0.0
4              0.0             0.0            -0.5            0.0

   ct_weapon_mac10  t_weapon_mac10  ct_weapon_mag7  t_weapon_mag7  \
0              0.0             0.0             0.0            0.0
1              0.0             0.0             0.0            0.0
2              0.0             0.0             0.0            0.0
3              0.0             0.0             0.0            0.0
4              0.0             0.0             0.0            0.0

   ct_weapon_mp5sd  t_weapon_mp5sd  ct_weapon_mp7  t_weapon_mp7  \
0              0.0             0.0            0.0           0.0
1              0.0             0.0            0.0           0.0
2              0.0             0.0            0.0           0.0
3              0.0             0.0            0.0           0.0
4              0.0             0.0            0.0           0.0

   ct_weapon_mp9  t_weapon_mp9  ct_weapon_negev  t_weapon_negev  \
0            0.0           0.0              0.0             0.0
1            0.0           0.0              0.0             0.0
2            0.0           0.0              0.0             0.0
3            0.0           0.0              0.0             0.0
4            0.0           0.0              0.0             0.0

   ct_weapon_nova  t_weapon_nova  ct_weapon_p90  t_weapon_p90  \
0             0.0            0.0            0.0           0.0
1             0.0            0.0            0.0           0.0
2             0.0            0.0            0.0           0.0
3             0.0            0.0            0.0           0.0
4             0.0            0.0            0.0           0.0

   ct_weapon_r8revolver  t_weapon_r8revolver  ct_weapon_sawedoff  \
0                   0.0                  0.0                 0.0
1                   0.0                  0.0                 0.0
2                   0.0                  0.0                 0.0
3                   0.0                  0.0                 0.0
4                   0.0                  0.0                 0.0

   t_weapon_sawedoff  ct_weapon_scar20  t_weapon_scar20  ct_weapon_sg553  \
0                0.0               0.0              0.0              0.0
1                0.0               0.0              0.0              0.0
2                0.0               0.0              0.0              0.0
3                0.0               0.0              0.0              0.0
4                0.0               0.0              0.0              0.0
```

```
   t_weapon_sg553  ct_weapon_ssg08  t_weapon_ssg08  ct_weapon_ump45  \
0             0.0              0.0             0.0              0.0
1             0.0              0.0             0.0              0.0
2             0.0              0.0             0.0              0.0
3             0.0              0.0             0.0              0.0
4             0.0              0.0             0.0              0.0

   t_weapon_ump45  ct_weapon_xm1014  t_weapon_xm1014  ct_weapon_deagle  \
0             0.0               0.0              0.0               0.0
1             0.0               0.0              0.0               0.0
2             0.0               0.0              0.0               0.0
3             0.0               0.0              0.0               0.0
4             0.0               0.0              0.0               0.0

   t_weapon_deagle  ct_weapon_fiveseven  t_weapon_fiveseven  ct_weapon_usps  \
0              0.0                  0.0                 0.0        0.333333
1              0.0                  0.0                 0.0        0.333333
2              0.0                  0.0                 0.0        0.333333
3              0.0                  0.0                 0.0        0.333333
4              0.0                  0.0                 0.0        0.333333

   t_weapon_usps  ct_weapon_p250  t_weapon_p250  ct_weapon_p2000  \
0            0.0             0.0            0.0              1.0
1            0.0             0.0            0.0              1.0
2            0.0             0.0            0.0              0.0
3            0.0             0.0            0.0              0.0
4            0.0             0.0            0.0              1.0

   t_weapon_p2000  ct_weapon_tec9  t_weapon_tec9  ct_grenade_hegrenade  \
0             0.0             0.0            0.0                   0.0
1             0.0             0.0            0.0                   0.0
2             0.0             0.0            0.0                   0.0
3             1.0             0.0            0.0                   0.0
4             0.0             0.0            0.0                   0.0

   t_grenade_hegrenade  ct_grenade_flashbang  t_grenade_flashbang  \
0                  0.0             -0.333333            -0.333333
1                  0.0             -0.333333            -0.333333
2                  0.0             -0.333333            -0.333333
3                  0.0             -0.333333            -0.333333
4                  0.0             -0.333333            -0.333333

   ct_grenade_smokegrenade  t_grenade_smokegrenade  \
0                -0.333333               -0.333333
1                -0.333333                0.333333
2                -0.333333                0.333333
```

```
3                -0.333333               -0.333333
4                -0.333333               -0.333333

   ct_grenade_incendiarygrenade  t_grenade_incendiarygrenade  \
0                           0.0                          0.0
1                           0.0                          0.0
2                           0.0                          0.0
3                           0.0                          0.0
4                           0.0                          0.0

   ct_grenade_molotovgrenade  t_grenade_molotovgrenade  \
0                        0.0                      -0.5
1                        0.0                      -0.5
2                        0.0                      -0.5
3                        0.0                      -0.5
4                        0.0                      -0.5

   ct_grenade_decoygrenade  t_grenade_decoygrenade
0                      0.0                     0.0
1                      0.0                     0.0
2                      0.0                     0.0
3                      0.0                     0.0
4                      0.0                     0.0
```

1.5.1 Wybór atrybutów

W pierwszej kolejności sprawdzimy, które atrybuty mają największy wpływ na klasy.

W tym celu wykorzystamy model *Random Forest Regressor*, który dopasowuje szereg klasyfikujących drzew decyzyjnych do różnych podpróbek zbioru danych i wykorzystuje uśrednianie w celu poprawy dokładności predykcyjnej i kontroli nadmiernego dopasowania.

```
[17]: rf = RandomForestRegressor(n_estimators=150, n_jobs=-1)
      rf.fit(x, y)
```

```
[17]: RandomForestRegressor(n_estimators=150, n_jobs=-1)
```

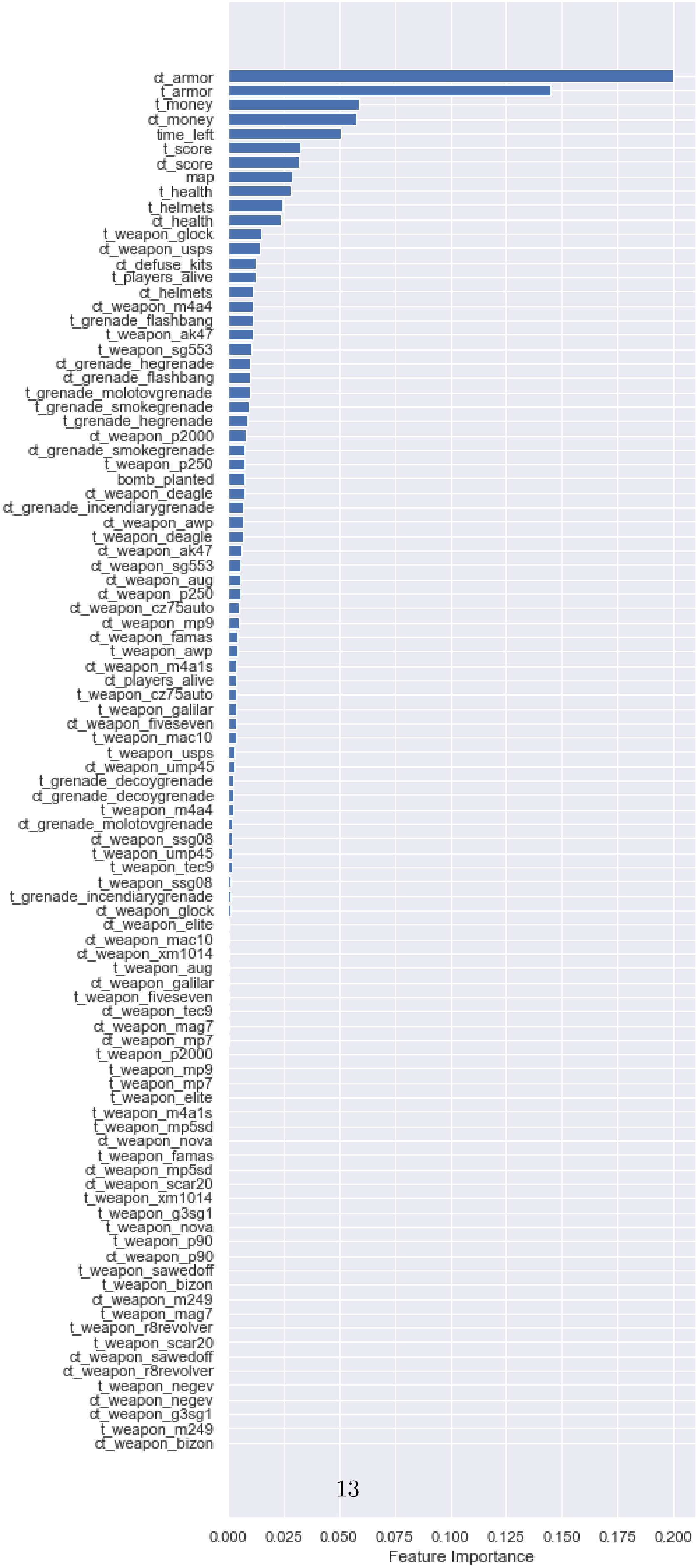
Po stworzeniu i wyuczeniu modelu sortujemy tablice zawierającą informacje o tym, jak duży wpływ mają konkretne atrybuty w podejmowaniu decyzji.

```
[18]: indexes = rf.feature_importances_.argsort()
```

Wpływ poszczególnych atrybutów został przedstawiony na poniższym wykresie.

```
[19]: plt.figure(figsize=(6,20))
      plt.barh(x.columns[indexes], rf.feature_importances_[indexes])
      plt.xlabel("Feature Importance")
```

```
[19]: Text(0.5, 0, 'Feature Importance')
```


ct_armor
t_armor
t_money
ct_money
time_left
t_score
ct_score
map
t_health
t_helmets
ct_health
t_weapon_glock
ct_weapon_usps
ct_defuse_kits
t_players_alive
ct_helmets
ct_weapon_m4a4
t_grenade_flashbang
t_weapon_ak47
t_weapon_sg553
ct_grenade_hegrenade
ct_grenade_flashbang
t_grenade_molotovgrenade
t_grenade_smokegrenade
t_grenade_hegrenade
ct_weapon_p2000
ct_grenade_smokegrenade
t_weapon_p250
bomb_planted
ct_weapon_deagle
ct_grenade_incendiarygrenade
ct_weapon_awp
t_weapon_deagle
ct_weapon_ak47
ct_weapon_sg553
ct_weapon_aug
ct_weapon_p250
ct_weapon_cz75auto
ct_weapon_mp9
ct_weapon_famas
t_weapon_awp
ct_weapon_m4a1s
ct_players_alive
t_weapon_cz75auto
t_weapon_galilar
ct_weapon_fiveseven
t_weapon_mac10
t_weapon_usps
ct_weapon_ump45
t_grenade_decoygrenade
ct_grenade_decoygrenade
t_weapon_m4a4
ct_grenade_molotovgrenade
ct_weapon_ssg08
t_weapon_ump45
t_weapon_tec9
t_weapon_ssg08
t_grenade_incendiarygrenade
ct_weapon_glock
ct_weapon_elite
ct_weapon_mac10
ct_weapon_xm1014
t_weapon_aug
ct_weapon_galilar
t_weapon_fiveseven
ct_weapon_tec9
ct_weapon_mag7
ct_weapon_mp7
t_weapon_p2000
t_weapon_mp9
t_weapon_mp7
t_weapon_elite
t_weapon_m4a1s
t_weapon_mp5sd
ct_weapon_nova
t_weapon_famas
ct_weapon_mp5sd
ct_weapon_scar20
t_weapon_xm1014
t_weapon_g3sg1
t_weapon_nova
t_weapon_p90
ct_weapon_p90
t_weapon_sawedoff
t_weapon_bizon
ct_weapon_m249
t_weapon_mag7
t_weapon_r8revolver
t_weapon_scar20
ct_weapon_sawedoff
ct_weapon_r8revolver
t_weapon_negev
ct_weapon_negev
ct_weapon_g3sg1
t_weapon_m249
ct_weapon_bizon
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Feature Importance

Następnie możemy odrzucić te atrybuty, które mają niski wpływ na podejmowanie decyzji lub nie mają żadnego. W tym celu wybraliśmy te atrybuty, dla których wartość parametru *feature_importance* jest większa od wartości 0,005.

[20]:

```
importances = rf.feature_importances_[indexes]
indexes = indexes[np.argwhere(importances > 0.005)]
indexes = np.concatenate(indexes).ravel().tolist()
columns = x.columns[indexes]
x = x[columns]
```

W tym momencie możemy sprawdzić liczbę atrybutów pozostałych po selekcji.

[21]:

```
x.shape
```

[21]:

```
(122410, 38)
```

Mamy 38 atrybutów, które prezentują się jak w poniższej tabeli.

[22]:

```
x.head()
```

[22]:

```
   ct_weapon_cz75auto  ct_weapon_p250  ct_weapon_aug  ct_weapon_sg553  \
0                 0.0             0.0            0.0              0.0
1                 0.0             0.0            0.0              0.0
2                 0.0             0.0            0.0              0.0
3                 0.0             0.0            0.0              0.0
4                 0.0             0.0            0.0              0.0

   ct_weapon_ak47  t_weapon_deagle  ct_weapon_awp  \
0             0.0              0.0            0.0
1             0.0              0.0            0.0
2             0.0              0.0            0.0
3             0.0              0.0            0.0
4             0.0              0.0            0.0

   ct_grenade_incendiarygrenade  ct_weapon_deagle  bomb_planted  \
0                           0.0               0.0           0.0
1                           0.0               0.0           0.0
2                           0.0               0.0           0.0
3                           0.0               0.0           0.0
4                           0.0               0.0           0.0

   t_weapon_p250  ct_grenade_smokegrenade  ct_weapon_p2000  \
0            0.0                -0.333333              1.0
1            0.0                -0.333333              1.0
2            0.0                -0.333333              0.0
3            0.0                -0.333333              0.0
```

```
4            0.0                -0.333333              1.0

   t_grenade_hegrenade  t_grenade_smokegrenade  t_grenade_molotovgrenade  \
0                  0.0               -0.333333                      -0.5   
1                  0.0                0.333333                      -0.5   
2                  0.0                0.333333                      -0.5   
3                  0.0               -0.333333                      -0.5   
4                  0.0               -0.333333                      -0.5   

   ct_grenade_flashbang  ct_grenade_hegrenade  t_weapon_sg553  t_weapon_ak47  \
0             -0.333333                   0.0             0.0           -0.5   
1             -0.333333                   0.0             0.0           -0.5   
2             -0.333333                   0.0             0.0           -0.5   
3             -0.333333                   0.0             0.0           -0.5   
4             -0.333333                   0.0             0.0           -0.5   

   t_grenade_flashbang  ct_weapon_m4a4  ct_helmets  t_players_alive  \
0            -0.333333            -0.5        -0.5              0.0   
1            -0.333333            -0.5        -0.5              0.0   
2            -0.333333            -0.5        -0.5             -1.0   
3            -0.333333            -0.5        -0.5             -1.0   
4            -0.333333            -0.5        -0.5              0.0   

   ct_defuse_kits  ct_weapon_usps  t_weapon_glock  ct_health  t_helmets  \
0       -0.333333        0.333333        0.333333   0.000000       -0.6   
1        0.000000        0.333333        0.333333   0.000000       -0.6   
2        0.000000        0.333333        0.000000  -0.726667       -0.6   
3        0.000000        0.333333       -0.333333  -0.726667       -0.6   
4        0.000000        0.333333        0.333333   0.000000       -0.6   

   t_health       map  ct_score   t_score  time_left  ct_money   t_money  \
0  0.000000 -0.666667 -0.857143 -0.857143   0.715105 -0.112782 -0.191489   
1  0.000000 -0.666667 -0.857143 -0.857143   0.545726 -0.368421 -0.395137   
2 -0.561798 -0.666667 -0.857143 -0.857143   0.010000 -0.357143 -0.404255   
3 -0.561798 -0.666667 -0.857143 -0.857143  -0.168575 -0.357143 -0.404255   
4  0.000000 -0.666667 -0.714286 -0.857143   0.714837  0.966165  0.218845   

    t_armor  ct_armor  
0 -1.136054 -1.291096  
1 -0.115646  0.078767  
2 -0.455782 -0.284247  
3 -0.455782 -0.284247  
4 -1.136054 -0.633562  
```

Mając już przetworzone dane, możemy wydzielić z nich zbiór treningowy oraz testowy.

[23]:
```
x_train, x_test, y_train, y_test = train_test_split(x, y, stratify = y,␣
 ↪test_size = 0.1, random_state = 0)
```

[24]:
```
x_train.shape
```

[24]:
```
(110169, 38)
```

[25]:
```
x_test.shape
```

[25]:
```
(12241, 38)
```

Jak widać na podstawie powyższych wywołań, mamy 110169 rekordów w zbiorze testowym oraz 12241 w zbiorze treningowym. W tym momencie możemy rozpocząć inicjalizacje modelu.

1.5.2 Model MLP

W celu inicjalizacji modelu zostanie wykorzystany klasyfikator MLP, zaimplementowany w bibliotece *scikit-learn* jako *MLPClassifier*.

MLPClassifier określa wielowarstwowy perceptron. W przeciwieństwie do innych algorytmów klasyfikacji, takich jak klasyfikator wektorów wspierających lub naiwny klasyfikator Bayesa, *MLPClassifier* przy wykonaniu zadania klasyfikacji opiera się na podstawowej sieci neuronowej.

Istotne cechy wielowarstwowego perceptronu MLP w bibliotece *scikit-learn*: - w warstwie wyjściowej nie ma funkcji aktywacji, - w przypadku scenariuszy regresji błąd kwadratowy jest funkcją straty, a entropia krzyżowa jest funkcją straty klasyfikacji, - może pracować z regresją pojedynczych, jak i wielu wartości docelowych, - w przeciwieństwie do innych popularnych pakietów, implementacja MLP w *scikit* nie obsługuje GPU, - nie jest możliwe dostrojenie parametrów, takich jak różne funkcje aktywacji, inicjatory wagi itp. dla każdej warstwy.

[26]:
```
nn_clf = MLPClassifier(verbose = True, warm_start=True, max_iter=1)
```

Opcja *verbose=True* powoduje, że na standardowe wyjście będą drukowane wiadomości o postępach w kolejnych iteracjach.

Ustawienie opcji *warm_start* na *True* oraz *max_iter* na *1* umożliwia zatrzymanie procesu uczenia na jednej epoce, dzięki czemu można będzie zobaczyć jak szybko uczy się model.

Następnie przechodzimy do dopasowania modelu do macierzy danych *x_train* i wyniku *y_train* dla dwustu epok, obliczając i zapamiętując wyniki dla zbioru treningowego i testowego.

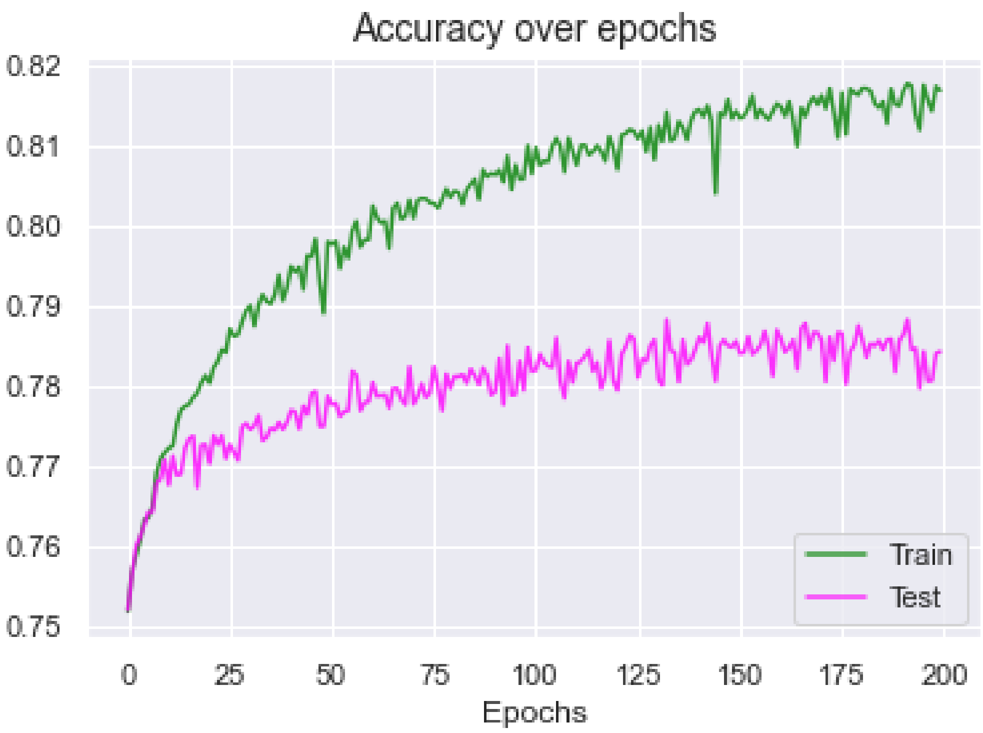
[27]:
```
scores_mlp_train = []
scores_mlp_test = []
for i in range(200):
    nn_clf.fit(x_train, y_train)
    scores_mlp_train.append(nn_clf.score(x_train, y_train))
    scores_mlp_test.append(nn_clf.score(x_test, y_test))
    print(f'Iteration {i + 1}, score = {nn_clf.score(x_test, y_test)}')
```

```
Iteration 1, loss = 0.48304638
Iteration 1, score = 0.7519810473000572

C:\Users\adasi\AppData\Local\pypoetry\Cache\virtualenvs\csgo-round-prediction-
GhoYBn2B-py3.10\lib\site-
packages\sklearn\neural_network\_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (1) reached and the
optimization hasn't converged yet.
  warnings.warn(

Iteration 2, loss = 0.45531088
Iteration 2, score = 0.7563924515970918
Iteration 3, loss = 0.44944033
Iteration 3, score = 0.759905236500286
Iteration 4, loss = 0.44529239
Iteration 4, score = 0.7610489339106282
Iteration 5, loss = 0.44248140
Iteration 5, score = 0.762601094681807
Iteration 6, loss = 0.44032367
Iteration 6, score = 0.7641532554529858
Iteration 7, loss = 0.43814777
Iteration 7, score = 0.7642349481251531
Iteration 8, loss = 0.43636235
Iteration 8, score = 0.7678294257005147
Iteration 9, loss = 0.43483083
Iteration 9, score = 0.7683195817335186
Iteration 10, loss = 0.43297083
Iteration 10, score = 0.7707703618985376
Iteration 11, loss = 0.43161232
Iteration 11, score = 0.7675843476840127
Iteration 12, loss = 0.43046747
Iteration 12, score = 0.7711788252593742
Iteration 13, loss = 0.42912346
Iteration 13, score = 0.7688097377665224
Iteration 14, loss = 0.42806524
Iteration 14, score = 0.768973123110857
Iteration 15, loss = 0.42679957
Iteration 15, score = 0.7721591373253819
Iteration 16, loss = 0.42575922
Iteration 16, score = 0.7733845274078915
Iteration 17, loss = 0.42454852
Iteration 17, score = 0.7737112980965607
Iteration 18, loss = 0.42377209
Iteration 18, score = 0.7672575769953435
Iteration 19, loss = 0.42276338
Iteration 19, score = 0.7725676006862184
Iteration 20, loss = 0.42196222
Iteration 20, score = 0.7726492933583857
Iteration 21, loss = 0.42093541
Iteration 21, score = 0.7702802058655338
Iteration 22, loss = 0.42009746
Iteration 22, score = 0.7737929907687281
Iteration 23, loss = 0.41940261
Iteration 23, score = 0.7726492933583857
Iteration 24, loss = 0.41875859
Iteration 24, score = 0.7737929907687281
Iteration 25, loss = 0.41804825
Iteration 25, score = 0.7709337472428723
Iteration 26, loss = 0.41708242
Iteration 26, score = 0.7726492933583857
Iteration 27, loss = 0.41643347
Iteration 27, score = 0.771668981292378
Iteration 28, loss = 0.41554629
Iteration 28, score = 0.7706886692263704
Iteration 29, loss = 0.41510362
Iteration 29, score = 0.7748549955069031
Iteration 30, loss = 0.41458452
Iteration 30, score = 0.7752634588677396
Iteration 31, loss = 0.41401973
Iteration 31, score = 0.7745282248182338
Iteration 32, loss = 0.41291744
Iteration 32, score = 0.7750183808512376
Iteration 33, loss = 0.41213917
Iteration 33, score = 0.7762437709337472
Iteration 34, loss = 0.41171740
Iteration 34, score = 0.7731394493913896
Iteration 35, loss = 0.41118649
Iteration 35, score = 0.7735479127522261
Iteration 36, loss = 0.41098518
Iteration 36, score = 0.7746916101625684
Iteration 37, loss = 0.41031233
Iteration 37, score = 0.7744465321460665
Iteration 38, loss = 0.40946225
Iteration 38, score = 0.7754268442120742
Iteration 39, loss = 0.40883469
Iteration 39, score = 0.7745282248182338
Iteration 40, loss = 0.40878372
Iteration 40, score = 0.7754268442120742
Iteration 41, loss = 0.40746862
Iteration 41, score = 0.7768973123110857
Iteration 42, loss = 0.40769313
Iteration 42, score = 0.776733926966751
Iteration 43, loss = 0.40744460
Iteration 43, score = 0.7746099174904011
Iteration 44, loss = 0.40648721
Iteration 44, score = 0.7774691610162568
Iteration 45, loss = 0.40648453
Iteration 45, score = 0.7764071562780819
Iteration 46, loss = 0.40593346
Iteration 46, score = 0.7790213217874357
Iteration 47, loss = 0.40515185
Iteration 47, score = 0.7792663998039376
Iteration 48, loss = 0.40473150
Iteration 48, score = 0.7749366881790704
Iteration 49, loss = 0.40467247
Iteration 49, score = 0.7749366881790704
Iteration 50, loss = 0.40447075
Iteration 50, score = 0.7786945510987664
Iteration 51, loss = 0.40382859
Iteration 51, score = 0.7776325463605914
Iteration 52, loss = 0.40312290
Iteration 52, score = 0.7777959317049261
Iteration 53, loss = 0.40239195
Iteration 53, score = 0.7761620782615799
Iteration 54, loss = 0.40203138
Iteration 54, score = 0.776733926966751
Iteration 55, loss = 0.40191788
Iteration 55, score = 0.7768973123110857
Iteration 56, loss = 0.40160361
Iteration 56, score = 0.7817988726411241
Iteration 57, loss = 0.40117991
Iteration 57, score = 0.7813087166081203
Iteration 58, loss = 0.40105949
Iteration 58, score = 0.7768973123110857
Iteration 59, loss = 0.40052801
Iteration 59, score = 0.7778776243770934
Iteration 60, loss = 0.40006302
Iteration 60, score = 0.778041009721428
Iteration 61, loss = 0.40010319
Iteration 61, score = 0.7804100972142799
Iteration 62, loss = 0.39934464
Iteration 62, score = 0.7786945510987664
Iteration 63, loss = 0.39998656
Iteration 63, score = 0.7787762437709338
Iteration 64, loss = 0.39884197
Iteration 64, score = 0.7788579364431011
Iteration 65, loss = 0.39863838
Iteration 65, score = 0.7772240829997549
Iteration 66, loss = 0.39790748
Iteration 66, score = 0.7796748631647741
Iteration 67, loss = 0.39757052
Iteration 67, score = 0.7796748631647741
Iteration 68, loss = 0.39748631
Iteration 68, score = 0.77828608773793
Iteration 69, loss = 0.39755209
Iteration 69, score = 0.7776325463605914
Iteration 70, loss = 0.39679115
Iteration 70, score = 0.7823707213462953
Iteration 71, loss = 0.39701380
Iteration 71, score = 0.7777142390327587
Iteration 72, loss = 0.39639885
Iteration 72, score = 0.7786945510987664
Iteration 73, loss = 0.39643356
Iteration 73, score = 0.7802467118699453
Iteration 74, loss = 0.39599294
Iteration 74, score = 0.7785311657544318
Iteration 75, loss = 0.39548189
Iteration 75, score = 0.779103014459603
Iteration 76, loss = 0.39551674
Iteration 76, score = 0.7823707213462953
Iteration 77, loss = 0.39542562
Iteration 77, score = 0.779919941181276
Iteration 78, loss = 0.39561553
Iteration 78, score = 0.7768973123110857
Iteration 79, loss = 0.39457466
Iteration 79, score = 0.7814721019524549
Iteration 80, loss = 0.39433387
Iteration 80, score = 0.7796748631647741
Iteration 81, loss = 0.39399993
Iteration 81, score = 0.7811453312637856
Iteration 82, loss = 0.39380112
Iteration 82, score = 0.7811453312637856
Iteration 83, loss = 0.39374429
Iteration 83, score = 0.7813904092802876
Iteration 84, loss = 0.39345340
Iteration 84, score = 0.7803284045421126
Iteration 85, loss = 0.39325651
Iteration 85, score = 0.782043950657626
Iteration 86, loss = 0.39295653
Iteration 86, score = 0.7812270239359529
Iteration 87, loss = 0.39293269
Iteration 87, score = 0.7801650191977779
Iteration 88, loss = 0.39270894
Iteration 88, score = 0.7822073360019606
Iteration 89, loss = 0.39269217
Iteration 89, score = 0.7813087166081203
Iteration 90, loss = 0.39190012
Iteration 90, score = 0.7788579364431011
Iteration 91, loss = 0.39163829
Iteration 91, score = 0.7792663998039376
Iteration 92, loss = 0.39188425
Iteration 92, score = 0.7834327260844702
Iteration 93, loss = 0.39180815
Iteration 93, score = 0.7776325463605914
Iteration 94, loss = 0.39145954
Iteration 94, score = 0.784984886855649
Iteration 95, loss = 0.39104062
Iteration 95, score = 0.7788579364431011
Iteration 96, loss = 0.39142644
Iteration 96, score = 0.7789396291152684
Iteration 97, loss = 0.39033943
Iteration 97, score = 0.7830242627236337
Iteration 98, loss = 0.39077416
Iteration 98, score = 0.7794297851482722
Iteration 99, loss = 0.39023198
Iteration 99, score = 0.7847398088391472
Iteration 100, loss = 0.39030439
Iteration 100, score = 0.7817988726411241
Iteration 101, loss = 0.38996142
Iteration 101, score = 0.7819622579854587
Iteration 102, loss = 0.38971042
Iteration 102, score = 0.7839228821174741
Iteration 103, loss = 0.38956299
Iteration 103, score = 0.7829425700514664
Iteration 104, loss = 0.38925026
Iteration 104, score = 0.7824524140184625
Iteration 105, loss = 0.38932151
Iteration 105, score = 0.782289028674128
Iteration 106, loss = 0.38909313
Iteration 106, score = 0.7859651989216567
Iteration 107, loss = 0.38894666
Iteration 107, score = 0.7804917898864472
Iteration 108, loss = 0.38857273
Iteration 108, score = 0.7784494730822645
Iteration 109, loss = 0.38860105
Iteration 109, score = 0.7830242627236337
Iteration 110, loss = 0.38830965
Iteration 110, score = 0.7804100972142799
Iteration 111, loss = 0.38777930
Iteration 111, score = 0.7827791847071318
Iteration 112, loss = 0.38777608
Iteration 112, score = 0.7830242627236337
Iteration 113, loss = 0.38740522
Iteration 113, score = 0.7836778041009721
Iteration 114, loss = 0.38765931
Iteration 114, score = 0.7844947308226452
Iteration 115, loss = 0.38772907
Iteration 115, score = 0.7817988726411241
Iteration 116, loss = 0.38720848
Iteration 116, score = 0.7828608773792991
Iteration 117, loss = 0.38716167
Iteration 117, score = 0.7796748631647741
Iteration 118, loss = 0.38683493
Iteration 118, score = 0.7812270239359529
Iteration 119, loss = 0.38733904
Iteration 119, score = 0.7856384282329875
Iteration 120, loss = 0.38654546
Iteration 120, score = 0.7805734825586145
Iteration 121, loss = 0.38654408
Iteration 121, score = 0.7794297851482722
Iteration 122, loss = 0.38647252
Iteration 122, score = 0.7839228821174741
Iteration 123, loss = 0.38655580
Iteration 123, score = 0.7849031941834818
Iteration 124, loss = 0.38607105
Iteration 124, score = 0.786291969610326
Iteration 125, loss = 0.38546065
Iteration 125, score = 0.7858018135773222
Iteration 126, loss = 0.38617359
Iteration 126, score = 0.7810636385916183
Iteration 127, loss = 0.38562926
Iteration 127, score = 0.7833510334123029
Iteration 128, loss = 0.38613696
Iteration 128, score = 0.7830242627236337
Iteration 129, loss = 0.38603855
Iteration 129, score = 0.784984886855649
Iteration 130, loss = 0.38502028
Iteration 130, score = 0.7857201209051549
Iteration 131, loss = 0.38567017
Iteration 131, score = 0.7807368679029492
Iteration 132, loss = 0.38498753
Iteration 132, score = 0.7800833265256106
Iteration 133, loss = 0.38496486
Iteration 133, score = 0.7882525937423414
Iteration 134, loss = 0.38454651
Iteration 134, score = 0.7843313454783106
Iteration 135, loss = 0.38478016
Iteration 135, score = 0.7841679601339759
Iteration 136, loss = 0.38458143
Iteration 136, score = 0.7804917898864472
Iteration 137, loss = 0.38462924
Iteration 137, score = 0.7857201209051549
Iteration 138, loss = 0.38450033
Iteration 138, score = 0.7826974920349644
Iteration 139, loss = 0.38442705
Iteration 139, score = 0.7831876480679683
Iteration 140, loss = 0.38414316
Iteration 140, score = 0.7844947308226452
Iteration 141, loss = 0.38414849
Iteration 141, score = 0.786046891593824
Iteration 142, loss = 0.38424634
Iteration 142, score = 0.7853933502164856
Iteration 143, loss = 0.38329087
Iteration 143, score = 0.7877624377093375
Iteration 144, loss = 0.38398212
Iteration 144, score = 0.7838411894453068
Iteration 145, loss = 0.38360721
Iteration 145, score = 0.7805734825586145
Iteration 146, loss = 0.38353255
Iteration 146, score = 0.784984886855649
Iteration 147, loss = 0.38328184
Iteration 147, score = 0.7857201209051549
Iteration 148, loss = 0.38324438
Iteration 148, score = 0.784984886855649
Iteration 149, loss = 0.38310044
Iteration 149, score = 0.7848215015113145
Iteration 150, loss = 0.38333210
Iteration 150, score = 0.7855567355608202
Iteration 151, loss = 0.38275769
Iteration 151, score = 0.7840045747896414
Iteration 152, loss = 0.38282136
Iteration 152, score = 0.7841679601339759
Iteration 153, loss = 0.38285296
Iteration 153, score = 0.7861285842659913
Iteration 154, loss = 0.38298842
Iteration 154, score = 0.7839228821174741
Iteration 155, loss = 0.38281259
Iteration 155, score = 0.7843313454783106
Iteration 156, loss = 0.38242250
Iteration 156, score = 0.7850665795278163
Iteration 157, loss = 0.38256364
Iteration 157, score = 0.7867821256433298
Iteration 158, loss = 0.38239098
Iteration 158, score = 0.7848215015113145
Iteration 159, loss = 0.38208493
Iteration 159, score = 0.7812270239359529
Iteration 160, loss = 0.38211172
Iteration 160, score = 0.7869455109876644
Iteration 161, loss = 0.38223036
Iteration 161, score = 0.7858835062494894
Iteration 162, loss = 0.38239856
Iteration 162, score = 0.7841679601339759
Iteration 163, loss = 0.38170069
Iteration 163, score = 0.7847398088391472
Iteration 164, loss = 0.38215295
Iteration 164, score = 0.7857201209051549
Iteration 165, loss = 0.38127229
Iteration 165, score = 0.782043950657626
Iteration 166, loss = 0.38146434
Iteration 166, score = 0.7871905890041663
Iteration 167, loss = 0.38154105
Iteration 167, score = 0.7877624377093375
Iteration 168, loss = 0.38115270
Iteration 168, score = 0.7846581161669798
Iteration 169, loss = 0.38149591
Iteration 169, score = 0.7866187402989951
Iteration 170, loss = 0.38119897
Iteration 170, score = 0.7866187402989951
Iteration 171, loss = 0.38085779
Iteration 171, score = 0.7856384282329875
Iteration 172, loss = 0.38155405
Iteration 172, score = 0.7804917898864472
Iteration 173, loss = 0.38099045
Iteration 173, score = 0.786046891593824
Iteration 174, loss = 0.38086916
Iteration 174, score = 0.783105955395801
Iteration 175, loss = 0.38113833
Iteration 175, score = 0.7866187402989951
Iteration 176, loss = 0.38069056
Iteration 176, score = 0.7865370476268279
Iteration 177, loss = 0.38031419
Iteration 177, score = 0.7802467118699453
Iteration 178, loss = 0.38102921
Iteration 178, score = 0.7842496528061433
Iteration 179, loss = 0.38036198
Iteration 179, score = 0.7850665795278163
Iteration 180, loss = 0.38009549
Iteration 180, score = 0.7875173596928355
Iteration 181, loss = 0.38050444
Iteration 181, score = 0.7857201209051549
Iteration 182, loss = 0.37978025
Iteration 182, score = 0.7835144187566375
Iteration 183, loss = 0.37999640
Iteration 183, score = 0.785229964872151
Iteration 184, loss = 0.38036370
Iteration 184, score = 0.784984886855649
Iteration 185, loss = 0.37994467
Iteration 185, score = 0.7856384282329875
Iteration 186, loss = 0.37996105
Iteration 186, score = 0.7844947308226452
Iteration 187, loss = 0.37969532
Iteration 187, score = 0.7857201209051549
Iteration 188, loss = 0.37961244
Iteration 188, score = 0.7858018135773222
Iteration 189, loss = 0.37984843
Iteration 189, score = 0.7817171799689567
Iteration 190, loss = 0.37955472
Iteration 190, score = 0.7856384282329875
Iteration 191, loss = 0.38023581
Iteration 191, score = 0.7863736622824933
Iteration 192, loss = 0.37948620
Iteration 192, score = 0.7882525937423414
Iteration 193, loss = 0.37942357
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs.
Stopping.
Iteration 193, score = 0.7844947308226452
Iteration 194, loss = 0.37933809
Training loss did not improve more than tol=0.000100 for 10 consecutive epochs.
Stopping.
Iteration 194, score = 0.7846581161669798
Iteration 195, loss = 0.37882986
Iteration 195, score = 0.7796748631647741
Iteration 196, loss = 0.37898010
Iteration 196, score = 0.7842496528061433
Iteration 197, loss = 0.37889837
Iteration 197, score = 0.7805734825586145
Iteration 198, loss = 0.37959929
Iteration 198, score = 0.7806551752307818
Iteration 199, loss = 0.37886890
Iteration 199, score = 0.7840045747896414
Iteration 200, loss = 0.37919533
Iteration 200, score = 0.7842496528061433
```

Otrzymane wyniki zostały zestawione na wykresie.

[48]:

```
plt.plot(scores_mlp_train, color='green', alpha=0.8, label='Train')
plt.plot(scores_mlp_test, color='magenta', alpha=0.8, label='Test')
plt.title("Accuracy over epochs", fontsize=14)
plt.xlabel('Epochs')
plt.legend(loc='lower right')
plt.show()
```



Jak widać, wraz z kolejnymi iteracjami dokładność się zwiększa, jednak dla zbioru testowego rezultaty są gorsze niż dla zbioru treningowego.

Ostatecznie, średnia trafność modelu na rozważanych danych testowych jest następująca:

```
[29]: print(f'Model sieci neuronowej: {nn_clf.score(x_test, y_test)}')
```

```
Model sieci neuronowej: 0.7842496528061433
```

1.6 Regresja logistyczna

Regresja logistyczna to algorytm nadzorowanego uczenia maszynowego używany do problemów z klasyfikacją binarną. Najlepszym sposobem myślenia o regresji logistycznej jest to, że jest to regresja liniowa, ale dla problemów z klasyfikacją. Podstawowa różnica między regresją liniową, a regresją logistyczną polega na tym, że zakres regresji logistycznej jest ograniczony od 0 do 1. Ponadto - w przeciwieństwie do regresji liniowej - regresja logistyczna nie wymaga liniowej zależności między zmiennymi wejściowymi i wyjściowymi.

```
[30]: log_model = LogisticRegression(verbose=True, n_jobs=-1, warm_start=True,␣
       ↪max_iter=1)
```

Analogicznie jak poprzednio testujemy model dla 200 iteracji.

```
[31]: scores_log_train = []
      scores_log_test = []
```

```python
for i in range(200):
    log_model.fit(x_train, y_train)
    scores_log_train.append(log_model.score(x_train, y_train))
    scores_log_test.append(log_model.score(x_test, y_test))
    print(f'Iteration {i + 1}, score = {log_model.score(x_test, y_test)}')
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    1.9s finished

Iteration 1, score = 0.7297606404705498

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 2, score = 0.7373580589821093

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 3, score = 0.7499387304958746

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 4, score = 0.7514908912670534

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 5, score = 0.7520627399722245

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.7s finished

Iteration 6, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 7, score = 0.7555755248754187

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.6s finished

Iteration 8, score = 0.7571276856465975

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 9, score = 0.7554938322032514

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 10, score = 0.7582713830569398
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 11, score = 0.7554938322032514

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 12, score = 0.7576995343517686

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 13, score = 0.755657217547586

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 14, score = 0.7572910709909321

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 15, score = 0.7567192222857609

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.1s finished

Iteration 16, score = 0.7578629196961033

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 17, score = 0.7563924515970918

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 18, score = 0.7548402908259129

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 19, score = 0.7566375296135937

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 20, score = 0.7561473735805898

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 21, score = 0.7560656809084225

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 22, score = 0.7567192222857609
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 23, score = 0.7559839882362552

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 24, score = 0.7565558369414264

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 25, score = 0.755657217547586

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 26, score = 0.7563924515970918

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 27, score = 0.7555755248754187

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 28, score = 0.7569643003022629

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 29, score = 0.755657217547586

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 30, score = 0.7565558369414264

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 31, score = 0.7554938322032514

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 32, score = 0.7569643003022629

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 33, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 34, score = 0.7570459929744302
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 35, score = 0.7554121395310841

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 36, score = 0.7570459929744302

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 37, score = 0.7548402908259129

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 38, score = 0.7572093783187648

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 39, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.1s finished

Iteration 40, score = 0.7563924515970918

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 41, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 42, score = 0.7557389102197533

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 43, score = 0.7563924515970918

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 44, score = 0.7555755248754187

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 45, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 46, score = 0.7546769054815783
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 47, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 48, score = 0.7548402908259129

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 49, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 50, score = 0.7550036761702476

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 51, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 52, score = 0.7550036761702476

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 53, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 54, score = 0.7548402908259129

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 55, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 56, score = 0.7546769054815783

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 57, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 58, score = 0.7548402908259129
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 59, score = 0.7550036761702476

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 60, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 61, score = 0.7550036761702476

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 62, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 63, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 64, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 65, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 66, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 67, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 68, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 69, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 70, score = 0.7546769054815783
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 71, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 72, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 73, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 74, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 75, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 76, score = 0.7554121395310841

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 77, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.7s finished

Iteration 78, score = 0.7554121395310841

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 79, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 80, score = 0.7553304468589167

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 81, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 82, score = 0.7553304468589167
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 83, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.5s finished

Iteration 84, score = 0.7553304468589167

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 85, score = 0.7552487541867494

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 86, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 87, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 88, score = 0.7551670615145821

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 89, score = 0.7550036761702476

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 90, score = 0.7549219834980803

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 91, score = 0.7550853688424148

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 92, score = 0.7546769054815783

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 93, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 94, score = 0.7540233641042399
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 95, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 96, score = 0.7540233641042399

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 97, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 98, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 99, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 100, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 101, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 102, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 103, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 104, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 105, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.3s finished

Iteration 106, score = 0.754350134792909
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 107, score = 0.7540233641042399

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.1s finished

Iteration 108, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 109, score = 0.7540233641042399

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 110, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 111, score = 0.7540233641042399

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 112, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 113, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 114, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 115, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 116, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 117, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 118, score = 0.7544318274650764
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 119, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 120, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 121, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 122, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 123, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 124, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 125, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 126, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 127, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 128, score = 0.7544318274650764

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 129, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 130, score = 0.7544318274650764
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 131, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 132, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 133, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 134, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 135, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 136, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 137, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 138, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 139, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 140, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 141, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 142, score = 0.7542684421207417
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 143, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 144, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 145, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 146, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 147, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 148, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 149, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.8s finished

Iteration 150, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 151, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 152, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 153, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 154, score = 0.7542684421207417
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 155, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 156, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 157, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 158, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 159, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 160, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 161, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 162, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.3s finished

Iteration 163, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.3s finished

Iteration 164, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 165, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 166, score = 0.7542684421207417
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 167, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 168, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 169, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 170, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 171, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 172, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 173, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 174, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 175, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.4s finished

Iteration 176, score = 0.754350134792909

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 177, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.5s finished

Iteration 178, score = 0.754350134792909
```

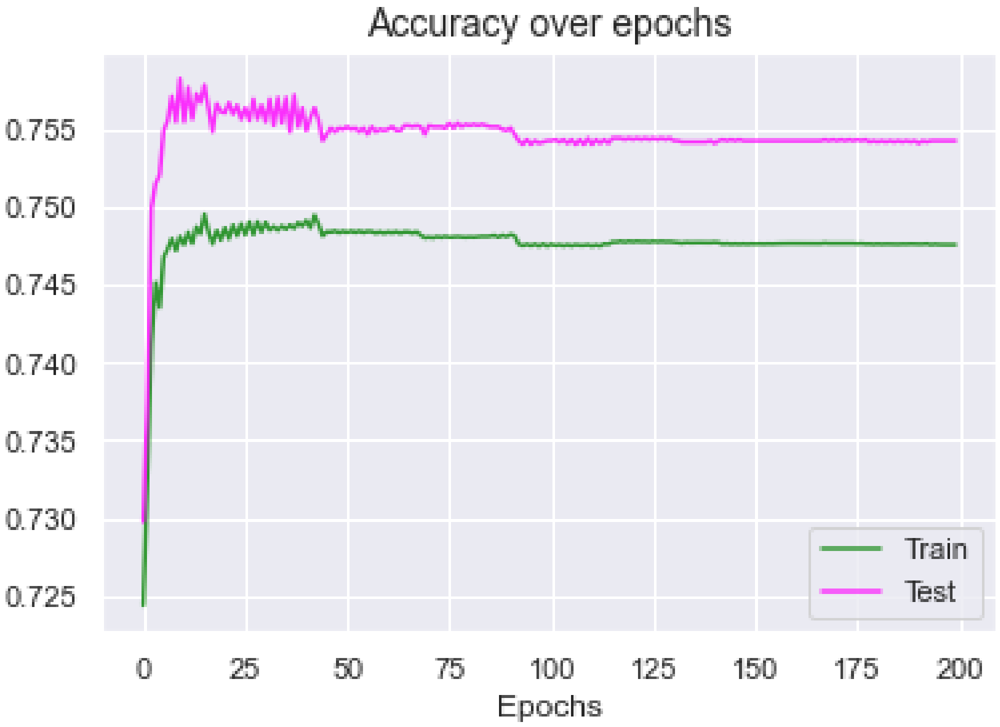
```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 179, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 180, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 181, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 182, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 183, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 184, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 185, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 186, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 187, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 188, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 189, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 190, score = 0.7542684421207417
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 191, score = 0.7541050567764072

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 192, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 193, score = 0.7541867494485744

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 194, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 195, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 196, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.3s finished

Iteration 197, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 198, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 199, score = 0.7542684421207417

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 out of   1 | elapsed:    0.2s finished

Iteration 200, score = 0.7542684421207417
```

W tym przypadku również stworzymy wykres.

[47]:

```
plt.plot(scores_log_train, color='green', alpha=0.8, label='Train')
plt.plot(scores_log_test, color='magenta', alpha=0.8, label='Test')
plt.title("Accuracy over epochs", fontsize=14)
plt.xlabel('Epochs')
plt.legend(loc='lower right')
plt.show()
```



Jak widać po niewielkiej liczbie iteracji znajdowane jest dość dobre rozwiązanie, po czym następuje niewielki spadek jakości rozwiązania, a następnie stopniowo wyrównuje się do wartości nieco gorszych niż na początku.

Ostatecznie, po wytrenowaniu modelu skuteczność na danych testowych jest następująca:

```
[33]: print(f"Model regresji logistycznej: {log_model.score(x_test, y_test)}")
```

```
Model regresji logistycznej: 0.7542684421207417
```

Regresja logistyczna okazała się trochę gorsza od modelu MLP, jednak czas trenowania modelu jest znacząco niższy.

1.7 Optymalizacja hiperparametrów

Powyższe algorytmy MLP i LR posiadają wiele konfigurowalnych hiperparametrów. W przypadku MLP są to m.in. funkcja aktywacji `activation`, przyrost uczenia `learning_rate` oraz `solver`. Dla LR są to m.in. `multi_class` oraz `solver`. Oczywiście dokładność modeli zależy od wartości tych hiperparametrów. W celu znalezienia kombinacji dającej najlepszej rezultaty posługujemy się biblioteką optuna. Optymalizatory zasadniczo stale zawężają przestrzeń poszukiwań, wykorzystując zapisy sugerowanych wartości parametrów i ocenianych wartości funkcji celu, co prowadzi do optymalnej przestrzeni poszukiwań, w której uzyskuje się parametry prowadzące do lepszych wartości funkcji celu. Domyślnym optymalizatorem jest Tree-structured Parzen Estimator.

1.7.1 Optymalizacja Multilayer Perceptron

[ ]:

```
import optuna
import sklearn.datasets

import sklearn.ensemble
import sklearn.model_selection
import sklearn.svm

def objective(trial):
    activation = trial.suggest_categorical("activation", ["identity",␣
  ↪"logistic", "tanh", "relu"])
    solver = trial.suggest_categorical("solver", ["lbfgs", "sgd", "adam"])
    learning_rate_init = trial.suggest_float("lri", 1e-5, 1e-2, log=True)
    learning_rate = "constant"
    if solver == "sgd":
        learning_rate = trial.suggest_categorical("learning_rate", ["constant",␣
  ↪"invscaling", "adaptive"])
    nn_clf = MLPClassifier(activation=activation, solver=solver,␣
  ↪warm_start=True, max_iter=1,
                           learning_rate=learning_rate,␣
  ↪learning_rate_init=learning_rate_init)
    for i in range(200):
        nn_clf.fit(x_train, y_train)
    return nn_clf.score(x_test, y_test)


study = optuna.create_study(direction='maximize')
study.optimize(objective, n_trials=100)
```

Dla algorytmu MLP najlepsze rezultaty są osiągane dla następujących hiperparametrów: ‘activation’: ‘relu’, ‘solver’: ‘adam’, ‘lri’: 0.004620094435728503. Skuteczność klasyfikatora wynosi wtedy 0.795.

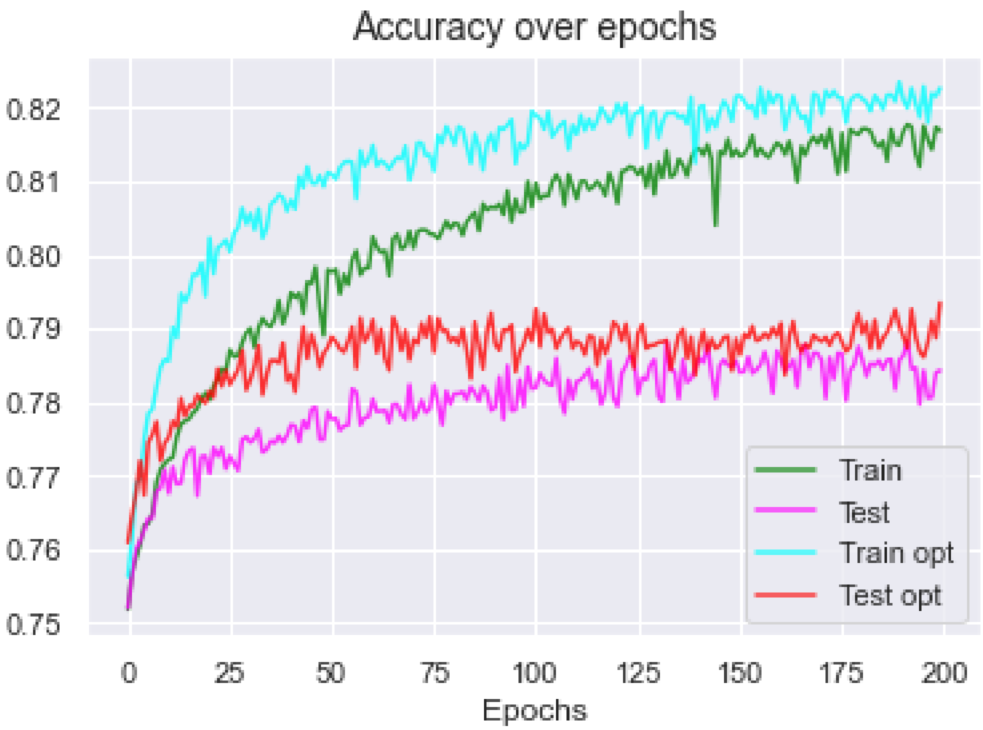
Na poniższym wykresie przedstawiono porównanie wcześniejszego modelu wraz z zopymalizowanym modelem.

[46]:

```
nn_clf_opt = MLPClassifier(warm_start=True, max_iter=1, activation='relu',␣
  ↪solver='adam',
                           learning_rate_init=0.004620094435728503)

scores_mlp_train_opt = []
scores_mlp_test_opt = []
for i in range(200):
    nn_clf_opt.fit(x_train, y_train)
    scores_mlp_train_opt.append(nn_clf_opt.score(x_train, y_train))
    scores_mlp_test_opt.append(nn_clf_opt.score(x_test, y_test))
```

```
plt.plot(scores_mlp_train, color='green', alpha=0.8, label='Train')
plt.plot(scores_mlp_test, color='magenta', alpha=0.8, label='Test')
plt.plot(scores_mlp_train_opt, color='cyan', alpha=0.8, label='Train opt')
plt.plot(scores_mlp_test_opt, color='red', alpha=0.8, label='Test opt')
plt.title("Accuracy over epochs", fontsize=14)
plt.xlabel('Epochs')
plt.legend(loc='lower right')
plt.show()
```

```
C:\Users\adasi\AppData\Local\pypoetry\Cache\virtualenvs\csgo-round-prediction-
GhoYBn2B-py3.10\lib\site-
packages\sklearn\neural_network\_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (1) reached and the
optimization hasn't converged yet.
  warnings.warn(
```



1.7.2 Optymalizacja Logistic Regression

```
[ ]: import optuna
     import sklearn.datasets

     import sklearn.ensemble
     import sklearn.model_selection
```

```python
import sklearn.svm

def objective(trial):
    solver = trial.suggest_categorical("solver", ["newton-cg", "lbfgs",␣
 ↪"liblinear", "sag", "saga"])
    if solver == "newton-cg":
        penalty = trial.suggest_categorical("ncg_pen", ["l2", "none"])
    elif solver == "lbfgs":
        penalty = trial.suggest_categorical("lbfgs_pen", ["l2", "none"])
    elif solver == "liblinear":
        penalty = trial.suggest_categorical("l1_pen", ["l1", "l2"])
    elif solver == "sag":
        penalty = trial.suggest_categorical("sag_pen", ["l2", "none"])
    elif solver == "saga":
        penalty = trial.suggest_categorical("saga_pen", ["elasticnet", "l1",␣
 ↪"l2", "none"])
    if solver == "liblinear":
        multi_class = trial.suggest_categorical("multiclass1", ["auto", "ovr"])
    else:
        multi_class = trial.suggest_categorical("multiclass2", ["auto", "ovr",␣
 ↪"multinomial"])

    l1_ratio = None
    if penalty == "elasticnet":
        l1_ratio = trial.suggest_float("l1r", 0, 1)

    nn_clf = LogisticRegression(solver=solver, warm_start=True, max_iter=1,␣
 ↪penalty=penalty,
                                multi_class=multi_class, l1_ratio=l1_ratio)
    for i in range(200):
        nn_clf.fit(x_train, y_train)
    return nn_clf.score(x_test, y_test)


study = optuna.create_study(direction='maximize')
study.optimize(objective, n_trials=100)
```

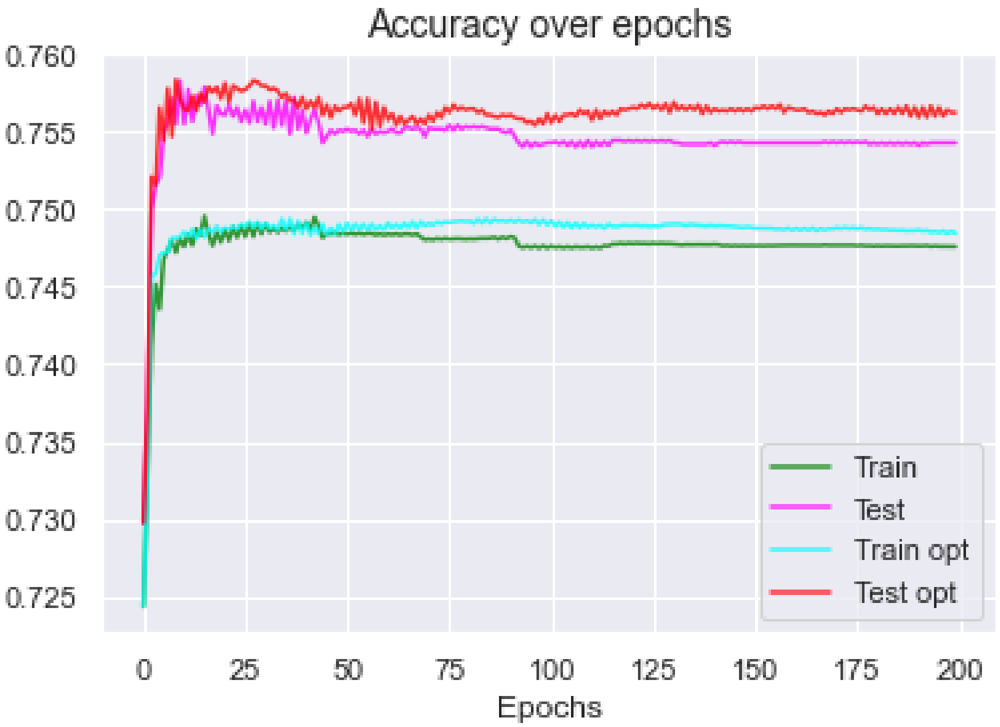
Dla algorytmu LR najlepsze rezultaty są osiągane dla następujących hiperparametrów: 'solver': 'lbfgs', 'penalty': 'l2', 'multi_class': 'multinomial'. Skuteczność klasyfikatora wynosi wtedy 0.756.

W przypadku algorytmu MLP następuje wzrost skuteczności klasyfikatora (0.784 -> 0.795). W przypadku LR optymalizacja hiperparametrów następuje nieznaczna poprawa (0.754 -> 0.756). Trenowanie LR trwa zauważalnie krócej - ok. 22 sekundy, a MLP ok. 2,5 minuty.

Na poniższym wykresie przedstawiono porównanie wcześniejszego modelu wraz z zopymalizowanym modelem.

[45]:

```
log_model_opt = LogisticRegression(n_jobs=-1, warm_start=True, max_iter=1, multi_class='multinomial',
                                   solver='lbfgs', penalty='l2')

scores_log_train_opt = []
scores_log_test_opt = []
for i in range(200):
    log_model_opt.fit(x_train, y_train)
    scores_log_train_opt.append(log_model_opt.score(x_train, y_train))
    scores_log_test_opt.append(log_model_opt.score(x_test, y_test))

plt.plot(scores_log_train, color='green', alpha=0.8, label='Train')
plt.plot(scores_log_test, color='magenta', alpha=0.8, label='Test')
plt.plot(scores_log_train_opt, color='cyan', alpha=0.8, label='Train opt')
plt.plot(scores_log_test_opt, color='red', alpha=0.8, label='Test opt')
plt.title("Accuracy over epochs", fontsize=14)
plt.xlabel('Epochs')
plt.legend(loc='lower right')
plt.show()
```



1.8 Podział prac

1. ~~Wybór niezbędnych bibliotek - Jakub Michalak~~

2. ~~Walidacja i wydzielenie danych treningowych - Damian Opoka~~
3. ~~Analiza i przygotowanie danych - Damian Opoka~~
4. ~~Definicja modelu - Adam Ryl~~
5. ~~*Weryfikacja krzyżowa - Adam Ryl*~~
6. ~~Dostosowanie hiperparametrów - Jakub Michalak~~
7. ~~Wygenerowanie wyników - Piotr Kryczka~~
8. ~~Analiza wyników - Piotr Kryczka~~