Лабораторная работа №1.

Обучение нейросетевых регрессора и классификаторов.
Вариант 2.

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1. Описание наборов данных.

Существует три основных набора данных, использованных в данной работе:

1. Общий набор данных для банка, который содержит информацию об клиентах банка. Это включает такие данные, как возраст, профессия, образование, семейное положение, наличие кредита и другие.

   bank-additional-full.csv - размеченный набор данных для бинарной классификации. Данные связаны с прямыми маркетинговыми кампаниями португальского банковского учреждения. Цель бинарной классификации состоит в том, чтобы предсказать, подпишется ли клиент на срочный банковский депозит (переменная y)

2. Набор данных о здоровье плода, который содержит данные по различным показателям, связанным со здоровьем плода в период беременности.

   fetal_health.csv - набор данных для многоклассовой классификации. Данный набор данных составлен из результатов кардиотокографии. Для этого мы создаем многоклассовую модель, чтобы классифицировать функции КТГ по трем состояниям здоровья плода: нормальное (1), подозрительное (2) и паталогическое (3).

3. Набор данных об энергетическом потреблении, который содержит информацию о потреблении энергии в разных областях.

   DS_2019_public.csv - набор данных для регрессии. Данный набор данных содержит информацию о потреблении энергии в зданиях. В этом наборе данных мы будем классифицировать по TOTALBTUCOL - общее потребление энергии для кондиционирования воздуха, в тысячах BTU. BTU - Британская тепловая единица.

2. Признаки, которые были использованы для анализа.

Признаки, используемые для анализа, преобразовывались и масштабировались в процессе предварительной обработки данных. В этом процессе категориальные признаки были преобразованы в числовые, а все признаки были приведены к одному масштабу.

В пункте А:

Признаки, использованные для анализа:

1. marital (семейное положение) был перекодирован в Marital Binary, где женатые/замужем получают 1, а все остальные получают 0.

2. default (есть ли у субъекта непогашенные кредиты) был перекодирован в Default Binary, где заемщики с кредитами в просрочке получают 1, а все остальные получают 0.
3. housing (имеет ли субъект ипотеку) был перекодирован в Housing Binary, где те, кто имеет ипотеку, получают 1, а все остальные получают 0.
4. loan (есть ли у субъекта личные заемные средства) был перекодирован в Loan Binary, где те, у кого есть личные заемные средства, получают 1, а все остальные получают 0.
5. poutcome (результат прошлой маркетинговой кампании) был перекодирован в Poutcome Binary, где успешные результаты получают 2, несуществующие получают 1, а все другие получают 0.
6. И остальные признаки которые не требовали перекодировки:

```
Data columns (total 21 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   age             41188 non-null  int64
 1   job             41188 non-null  object
 2   marital         41188 non-null  object
 3   education       41188 non-null  object
 4   default         41188 non-null  object
 5   housing         41188 non-null  object
 6   loan            41188 non-null  object
 7   contact         41188 non-null  object
 8   month           41188 non-null  object
 9   day_of_week     41188 non-null  object
 10  duration        41188 non-null  int64
 11  campaign        41188 non-null  int64
 12  pdays           41188 non-null  int64
 13  previous        41188 non-null  int64
 14  poutcome        41188 non-null  object
 15  emp.var.rate    41188 non-null  float64
 16  cons.price.idx  41188 non-null  float64
 17  cons.conf.idx   41188 non-null  float64
 18  euribor3m       41188 non-null  float64
 19  nr.employed     41188 non-null  float64
 20  y               41188 non-null  object
```

Следующие признаки были исключены из анализа:

1. y - Исключен, поскольку этот столбец был перекодирован в Target Binary и использовался в качестве целевого столбца для нашей задачи классификации.
2. job - Работа клиента, исключен, это связано с тем, что этот столбец является номинальным и требует дополнительной предварительной обработки, чтобы быть полезным для модели.
3. education - Образование клиента. Исключено теми же причинами, что и job.
4. contact - Способ связи с клиентом исключен по той же причине, что и job и education.
5. month, day_of_week - Месяц и день недели последнего контакта. Исключены из-за незначительного влияния на вероятность подписания депозита.

В пункте B:

Были использованы все признаки, кроме fetal_health, поскольку этот столбец был перекодирован в Target Multi и использовался в качестве целевого столбца для нашей задачи классификации. Эти данные представляют особенности здоровья плода, полученные на основе кардиографии плода

```
Data columns (total 22 columns):
 #   Column                                                  Non-Null Count  Dtype  
---  ------                                                  --------------  -----  
 0   baseline value                                          2126 non-null   float64
 1   accelerations                                           2126 non-null   float64
 2   fetal_movement                                          2126 non-null   float64
 3   uterine_contractions                                    2126 non-null   float64
 4   light_decelerations                                     2126 non-null   float64
 5   severe_decelerations                                    2126 non-null   float64
 6   prolongued_decelerations                                2126 non-null   float64
 7   abnormal_short_term_variability                         2126 non-null   float64
 8   mean_value_of_short_term_variability                    2126 non-null   float64
 9   percentage_of_time_with_abnormal_long_term_variability  2126 non-null   float64
 10  mean_value_of_long_term_variability                     2126 non-null   float64
 11  histogram_width                                         2126 non-null   float64
 12  histogram_min                                           2126 non-null   float64
 13  histogram_max                                           2126 non-null   float64
 14  histogram_number_of_peaks                               2126 non-null   float64
 15  histogram_number_of_zeroes                              2126 non-null   float64
 16  histogram_mode                                          2126 non-null   float64
 17  histogram_mean                                          2126 non-null   float64
 18  histogram_median                                        2126 non-null   float64
 19  histogram_variance                                      2126 non-null   float64
 20  histogram_tendency                                      2126 non-null   float64
 21  fetal_health                                            2126 non-null   float64
dtypes: float64(22)
```

В пункте C:

Для анализа использовались все столбцы набора данных "DS_2019_public.csv", кроме 'TOTALBTUCOL'. Этот столбец был выделен как целевая переменная (y), которую необходимо было предсказать, в то время как все остальные столбцы были использованы как признаки (X) для модели.

Остальные данные были предварительно обработаны (были удалены строки с некорректными значениями), затем прошли масштабирование при помощи MinMaxScaler (все признаки были приведены к диапазону между 0 и 1).

```
df.columns
```

```
Index(['Climate_Region_Pub', 'DIVISION', 'REPORTABLE_DOMAIN', 'DOLELCOL',
       'TOTALDOLCOL', 'KWHCOL', 'BTUELCOL', 'TOTALBTUCOL', 'TOTALDOLSPH',
       'TOTALBTUSPH',
       ...
       'LGT1EE', 'TOTALBTUWTH', 'ROOFTYPE', 'DOLELRFG', 'TOTALDOLRFG',
       'HEATROOM', 'WDWATER', 'UGWARM', 'DRYRFUEL', 'KWHRFG'],
      dtype='object', length=121)
```

```
df.dtypes
```

```
Climate_Region_Pub      int64
DIVISION                int64
REPORTABLE_DOMAIN       int64
DOLELCOL               object
TOTALDOLCOL             int64
                        ...
HEATROOM                int64
WDWATER                 int64
UGWARM                  int64
DRYRFUEL                int64
KWHRFG                float64
Length: 121, dtype: object
```

3. Параметры архитектур и обучения нейронных сетей, использованные для обучения.

Построены три различные модели: для бинарной классификации, многоклассовой классификации и регрессии.

Для каждой из них были использованы полносвязные нейронные сети. В модели бинарной классификации на последнем слое использовалась сигмоидная функция активации, в многоклассовой классификации - softmax, а в модели регрессии - линейная функция активации. Количество нейронов в скрытых слоях варьировалось в зависимости от модели.

А)

Архитектура сети: Сеть является бинарным классификатором и составлена из последовательности слоев (Sequential). Сначала добавляется Dense слой, который имеет 4 нейрона, с функцией активации ReLU, и принимающий на вход данные с 15 признаками. Затем следует еще один Dense слой с одним нейроном и функцией активации 'sigmoid', предназначенный для предоставления выходного значения.

Компиляция модели: Функция потерь, использованная в этой модели, - это бинарная кросс-энтропия, которая часто используется для задач бинарной классификации. Оптимизатор 'Adam' использовался для настройки весов модели. Метрика, используемая для оценки производительности модели в процессе обучения, - это точность(accuracy).

Обучение модели: Модель была обучена в течение 25 эпох, с размером пакета 10. Был использована валидационная выборка и коллбеки для ранней остановки и сохранения лучших весов модели. Режим валидации был поставлен на 'max' и показатель для проверки - 'val_accuracy'. Остановка обучения осуществляется, если нет улучшений в показателе 'val_accuracy' в течение 15 эпох.

B)

Архитектура сети: Аналогично предыдущему примеру, эта сеть создана с использованием модели последовательных слоев в Keras. Она также содержит два плотных слоя. Первый плотный слой имеет 8 нейронов с функцией активации ReLU. Второй - 4 нейрона с функцией активации "softmax". Функция активации "softmax" используется в задачах многоклассовой классификации, так как она предоставляет вероятностные оценки, которые суммируются в 1.

Компиляция модели: Сеть компилируется с функцией потерь "categorical_crossentropy", которая используется в задачах многоклассовой классификации. В качестве оптимизатора используется 'adam'. Метрика, используемая для оценки производительности модели, - 'accuracy'.

Обучение модели: Модель обучается в течение 50 эпох с размером пакета 20. Используются валидационные данные, а также коллбеки для ранней остановки и сохранения лучших весов модели. Показателем валидации является 'val_accuracy'. Мониторинг прекращается, если нет улучшения указанного показателя в течение 15 эпох.

C)

Архитектура нейронной сети: Создается последовательная модель в Keras, состоящаюдая из трех полносвязных слоев. Первый слой содержит 120 нейронов с функцией активации ReLU, второй слой состоит из 60 нейронов с функцией активации ReLU и на выходе один слой с линейной активацией. Функция активации ReLU используется для предотвращения проблемы затухания градиента, а линейная активация выбирается для задачи регрессии.

Компиляция модели: Модель компилируется с функцией потерь MSE (среднеквадратичная ошибка), использующуюся для задач регрессии, и оптимизатором Adam. Также отслеживается метрика MAE (средняя абсолютная ошибка).

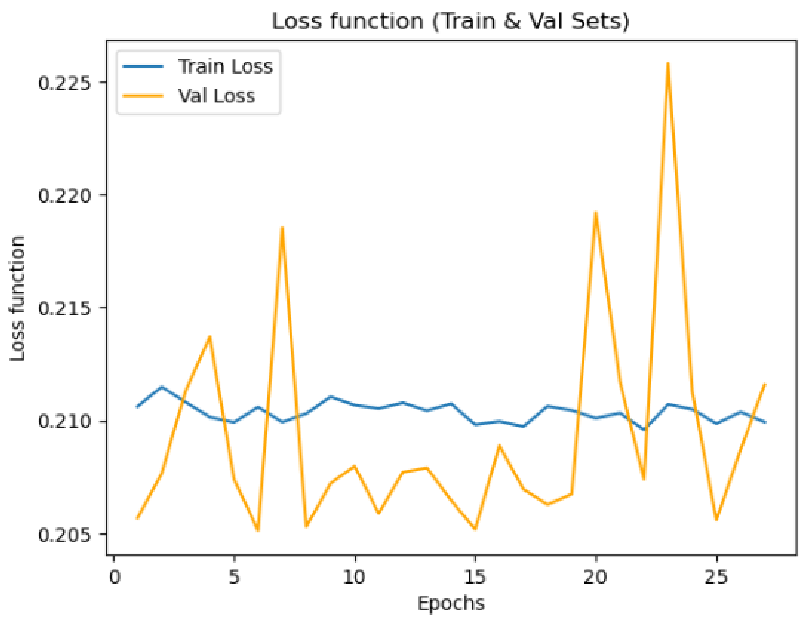
Обучение модели: Модель обучается в течение 350 эпох с размером пакета 40. Добавляются функции обратного вызова для ранней остановки обучения, если модель перестает улучшаться (с терпением в 20 эпох), и сохранения лучших весов модели. Валидационные данные используются в процессе обучения для оценки производительности модели на данных, которые она не видела.

4. Графики обучения для архитектур нейронных сетей с лучшими характеристиками эффективности

Графики обучения, представленные в коде, показывают как потери, так и точность модели в процессе обучения для тренировочного и валидационного набора данных.

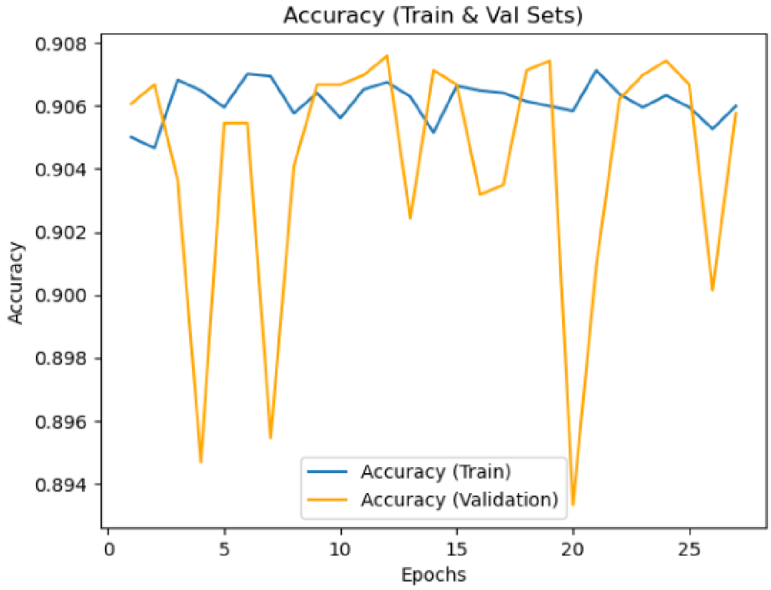
A)

```
loss_function = binary_classifier_history.history['loss']
val_loss_function = binary_classifier_history.history['val_loss']
epochs = range(1,len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs,loss_function,label='Train Loss')
plt.plot(epochs,val_loss_function,color='orange',label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```



Построение графика точности в процессе обучения

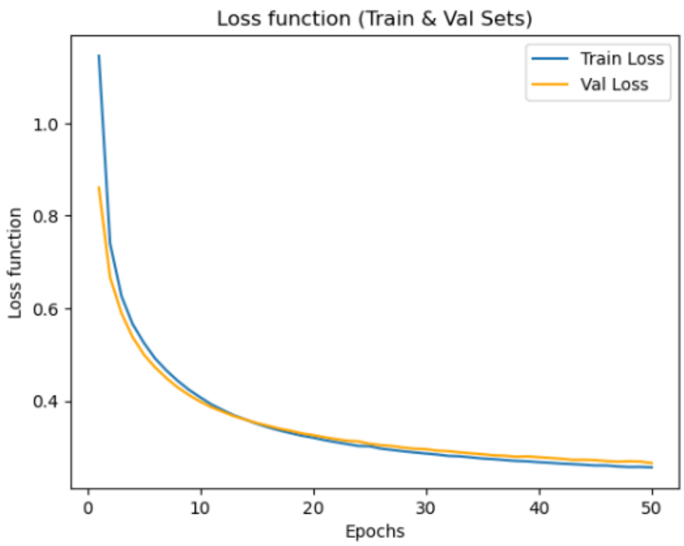
```
]: acc = binary_classifier_history.history['accuracy']
val_acc = binary_classifier_history.history['val_accuracy']
epochs = range(1,len(acc)+1)

plt.title('Accuracy (Train & Val Sets)')
plt.plot(epochs,acc,label='Accuracy (Train)')
plt.plot(epochs,val_acc,color='orange',label='Accuracy (Validation)')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



B)

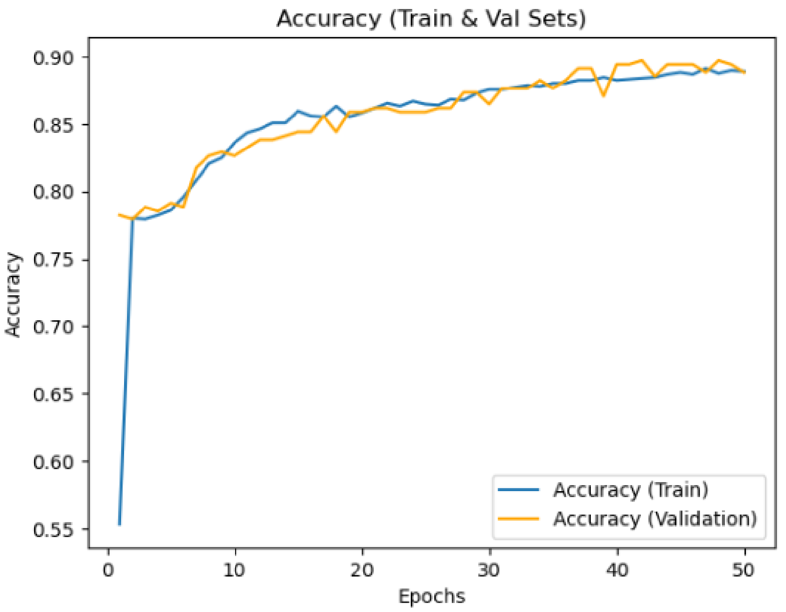
Построение графика потери

```
Ввод [38]: loss_function = multi_classifier_history.history['loss']
val_loss_function = multi_classifier_history.history['val_loss']
epochs = range(1,len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs,loss_function,label='Train Loss')
plt.plot(epochs,val_loss_function,color='orange',label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```



Построение графика точности

```
acc = multi_classifier_history.history['accuracy']
val_acc = multi_classifier_history.history['val_accuracy']
epochs = range(1,len(acc)+1)

plt.title('Accuracy (Train & Val Sets)')
plt.plot(epochs,acc,label='Accuracy (Train)')
plt.plot(epochs,val_acc,color='orange',label='Accuracy (Validation)')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



C)

Построение графика потери

Если функция потерь на тренировочной выборке продолжает уменьшаться, в то время как на валидационной выборке начинает возрастать, это является признаком переобучения

[31]:
```
loss_function = regressor_history.history['loss']
val_loss_function = regressor_history.history['val_loss']
epochs = range(1, len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs, loss_function, label='Train Loss')
plt.plot(epochs, val_loss_function, color='orange', label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```

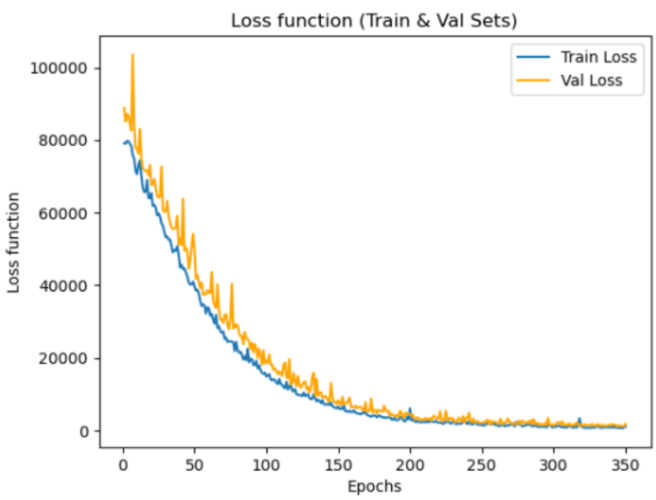
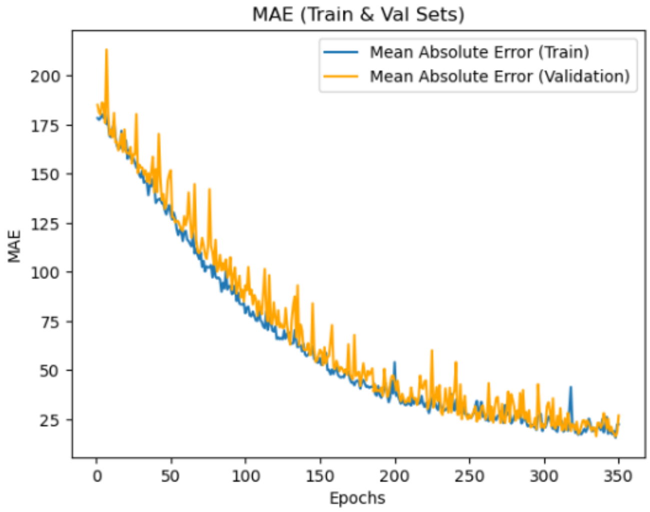


График изменения величины средней абсолютной ошибки (Mean Absolute Error, MAE) модели в процессе

Две кривые: одна для обучающего набора данных ("Mean Absolute Error (Train)") и для валидационного набора данных ("Mean Absolute Error (Validation)"). Если на графике видно, что ошибка на обучающей выборке продолжает уменьшаться, в то время как ошибка на валидационной выборке начинает увеличиваться, это может свидетельствовать о переобучении модели, когда она хорошо обучается на тренировочных данных, но плохо справляется с новыми, наблюдаемыми во время валидации данными.

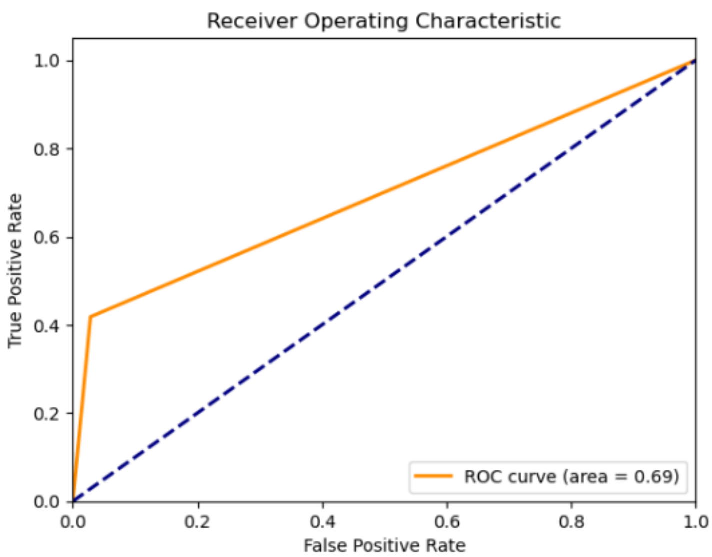
```
mae = regressor_history.history['mae']
val_mae = regressor_history.history['val_mae']
epochs = range(1, len(mae)+1)

plt.title('MAE (Train & Val Sets)')
plt.plot(epochs, mae, label='Mean Absolute Error (Train)')
plt.plot(epochs, val_mae, color='orange', label='Mean Absolute Error (Validation)')
plt.xlabel('Epochs')
plt.ylabel('MAE')
plt.legend()
plt.show()
```



5. ROC-кривые классов для лучших классификаторов.

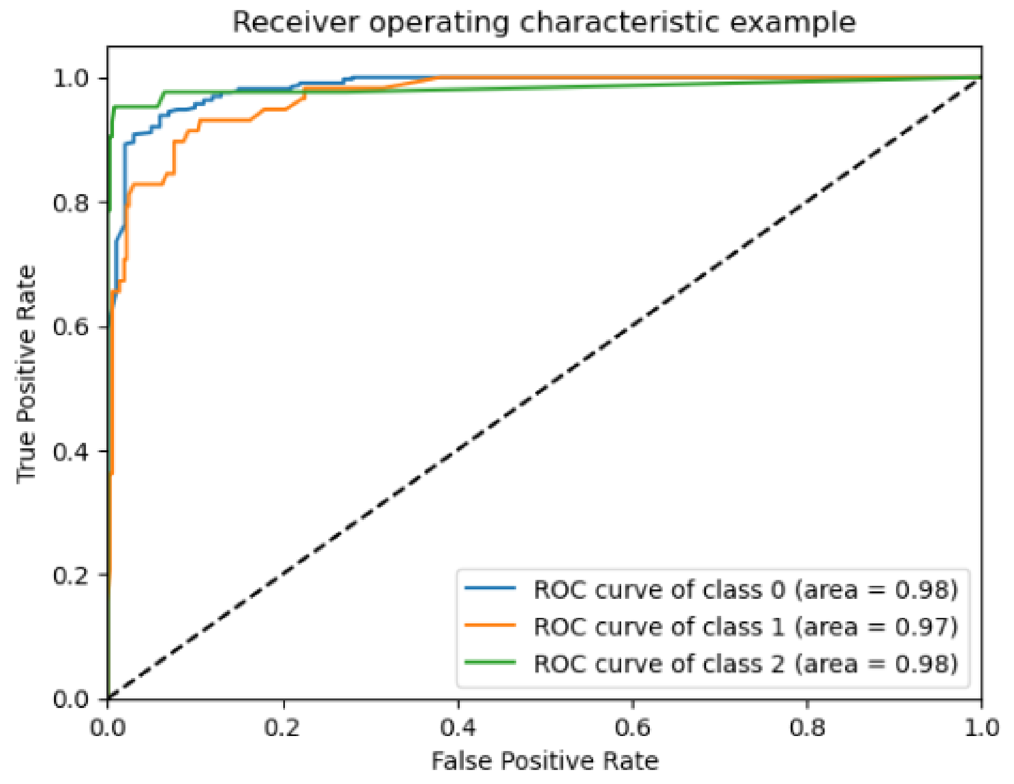
ROC-кривые, представленные в коде, дают визуализацию того, как хорошо наши бинарные и многоклассовые классификаторы справляются с обобщением на новые данные.

А)



	Recall	Precision	AUC	Weighted Accuracy
0	0.418103	0.652101	0.694893	0.909323

B)



6. Оценки моделей на тестовых выборках в виде таблиц/ диаграмм, отображающих метрики качества.

Оценки моделей, показанные в коде, включают такие метрики, как точность, полноту, MAE, MSE и коэффициент детерминации (R2).

Все указанные оценки были произведены на разделенных тестовых выборках, чтобы обеспечить корректное измерение эффективности модели. Графики позволяют визуально анализировать процесс обучения машины, а таблицы и диаграммы предоставляют числовые оценки метрик качества моделей.

Дополнительно вы можете обратить внимание на использование EarlyStopping и ModelCheckpoint, это обеспечивает сохранение лучшей модели и прекращение обучения в случае, если результаты не улучшаются на протяжении фиксированного количества эпох.

A)

1. Recall (полнота) равен 0.418, что означает, что модель правильно классифицировала только 41.8% положительных результатов из всех

истинных положительных результатов. Recall важен, когда ложно отрицательные результаты являются недопустимыми, и мы хотим минимизировать их количество.

2. Precision (точность) составляет 0.652, что означает, что модель верно классифицировала 65.2% от всех предсказанных положительных результатов. Precision важна, когда ложно положительные результаты являются недопустимыми, и мы хотим минимизировать их количество.

3. AUC (площадь под ROC-кривой) равна 0.695. ROC-кривая показывает зависимость между чувствительностью (True Positive Rate) и специфичностью (1 - False Positive Rate) модели при изменении порога классификации. AUC меряет общую производительность модели и должен быть максимально близким к 1.

4. Weighted Accuracy (взвешенная точность) составляет 0.909. Взвешенная точность учитывает дисбаланс классов в данных, присваивая вес каждому классу в зависимости от его доли в выборке.

Вывод: Модель имеет достаточно высокую точность и AUC, что может говорить о ее хорошей способности классифицировать данные. Однако полнота (recall) невысока, что означает, что модель может пропускать много истинно положительных результатов.

```
258/258 [==============================] - 1s
Recall: 0.41810344827586204
Precision: 0.6521008403361345
AUC: 0.6948930374074249
Weighted Accuracy: 0.9093226511289147
```

B)

1. Precision (точность): это метрика, показывающая, какая доля объектов, отнесённых моделью к классу 1, действительно относится к классу 1. Модель имеет точность 0.942, что свидетельствует о том, что почти 94.2% всех положительных предсказаний модели действительно верны.

2. Recall (полнота): это метрика, показывающая, какую часть объектов класса 1 из всех объектов класса 1 модель смогла обнаружить. Величина полноты в 0.9436 говорит о том, что модель идентифицировала почти 94.36% всех истинных положительных случаев.

3. AUC-ROC: AUC равен 0.979. Эта метрика говорит о том, насколько модель способна отличить положительные и отрицательные данные – чем ближе значение к 1, тем лучше. 0.979 – высокий показатель.

4. Weighted Accuracy также равно 0.944, что является высокой оценкой.

Вывод: Основываясь на этих данных, можно сказать, что мультиклассовый классификатор в рамках существующего набора данных работает отлично.

```
accuracy = accuracy_score(y_test, y_pred)
print("Weighted Accuracy: ", accuracy)
```

```
Precision:  0.9424434917086499
Recall:  0.9436619718309859
AUC:  0.9793782735877897
Weighted Accuracy:  0.9436619718309859
```

C)

1. MSE (Mean Squared Error, Средняя квадратическая ошибка) составляет 1588.58. MSE является общепризнанной мерой качества регрессионных предсказаний и чем меньше её значение, тем качественнее работает модель.

2. MAE (Mean Absolute Error, Средняя абсолютная ошибка) равна 28.06. Это абсолютное значение разности между реальными и прогнозными значениями. Чем меньше это число, тем лучше качество модели.

3. Коэффициент детерминации R^2 составляет почти 1 (0.99998), что является отличным значением и означает, что модель объясняет почти 100% вариации зависимой переменной.

Вывод: по представленным метрикам, модель показывает отличные результаты, причем коэффициент детерминации превосходно близок к 1.

```
MSE: 1588.583464797732
MAE: 28.06361318617011
R2: 0.9999828651563029
```

7. Программный код.

Лабораторная работа № 1

Боровских Вадим, 932003

А) Бинарный Классификатор bank-additional-full

In [1]:
```
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from keras.models import Sequential
from keras.layers import Dense
from keras.callbacks import ModelCheckpoint, EarlyStopping
```

In [2]:
```
df = pd.read_csv("bank-additional-full.csv",sep=";", quotechar='"', index_col = 0)
df=df.reset_index()
df
```

Out[2]:

	age	job	marital	education	default	housing	loan	contact	month	d
0	56	housemaid	married	basic.4y	no	no	no	telephone	may	
1	57	services	married	high.school	unknown	no	no	telephone	may	
2	37	services	married	high.school	no	yes	no	telephone	may	
3	40	admin.	married	basic.6y	no	no	no	telephone	may	
4	56	services	married	high.school	no	no	yes	telephone	may	
...	...	...	...	...	...	...	...	...	...	
41183	73	retired	married	professional.course	no	yes	no	cellular	nov	
41184	46	blue-collar	married	professional.course	no	no	no	cellular	nov	
41185	56	retired	married	university.degree	no	yes	no	cellular	nov	
41186	44	technician	married	professional.course	no	no	no	cellular	nov	
41187	74	retired	married	professional.course	no	yes	no	cellular	nov	

41188 rows × 21 columns

Возвращает названия всех столбцов в DataFrame

In [3]:
```
df.columns
```

Out[3]:
```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'emp.var.rate', 'cons.price.idx',
       'cons.conf.idx', 'euribor3m', 'nr.employed', 'y'],
      dtype='object')
```

Возвращает основную информации о DataFrame для определения, есть ли нулевые значения

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 41188 entries, 0 to 41187
Data columns (total 21 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   age             41188 non-null  int64  
 1   job             41188 non-null  object 
 2   marital         41188 non-null  object 
 3   education       41188 non-null  object 
 4   default         41188 non-null  object 
 5   housing         41188 non-null  object 
 6   loan            41188 non-null  object 
 7   contact         41188 non-null  object 
 8   month           41188 non-null  object 
 9   day_of_week     41188 non-null  object 
 10  duration        41188 non-null  int64  
 11  campaign        41188 non-null  int64  
 12  pdays           41188 non-null  int64  
 13  previous        41188 non-null  int64  
 14  poutcome        41188 non-null  object 
 15  emp.var.rate    41188 non-null  float64
 16  cons.price.idx  41188 non-null  float64
 17  cons.conf.idx   41188 non-null  float64
 18  euribor3m       41188 non-null  float64
 19  nr.employed     41188 non-null  float64
 20  y               41188 non-null  object 
dtypes: float64(5), int64(5), object(11)
memory usage: 6.6+ MB
```

Возвращает уникальные значения

In [5]:
```
df['y'].unique()
```

Out[5]:
```
array(['no', 'yes'], dtype=object)
```

Подсчет количества значений

In [6]:
```
df['y'].value_counts()
```

Out[6]:
```
no     36548
yes     4640
Name: y, dtype: int64
```

Перекодировка целевого столбца в бинарные значения и удаление исходного столбца:

In [7]:
```
df['marital'].value_counts()
```

Out[7]:
```
married     24928
single      11568
divorced     4612
unknown        80
Name: marital, dtype: int64
```

In [8]:
```
risk_dictionary_binary_class = {'married': 1, 'single': 0, 'divorced': 0, 'unknown'
df['Marital Binary'] = df['marital'].map(risk_dictionary_binary_class)
```

```
df[['marital','Marital Binary']].head(41188)
```

Out[8]:

	marital	Marital Binary
0	married	1
1	married	1
2	married	1
3	married	1
4	married	1
...	...	...
41183	married	1
41184	married	1
41185	married	1
41186	married	1
41187	married	1

41188 rows × 2 columns

In [9]:
```
df['default'].value_counts()
```

Out[9]:
```
no         32588
unknown     8597
yes            3
Name: default, dtype: int64
```

In [10]:
```
risk_dictionary_binary_class = {'yes': 1,'no': 0, 'unknown': 0}
df['Default Binary'] = df['default'].map(risk_dictionary_binary_class)
df[['default','Default Binary']].head(41188)
```

Out[10]:

	default	Default Binary
0	no	0
1	unknown	0
2	no	0
3	no	0
4	no	0
...	...	...
41183	no	0
41184	no	0
41185	no	0
41186	no	0
41187	no	0

41188 rows × 2 columns

In [11]:
```
df['housing'].value_counts()
```

Out[11]:
```
yes        21576
no         18622
unknown      990
Name: housing, dtype: int64
```

In [12]:
```
risk_dictionary_binary_class = {'yes': 1,'no': 0, 'unknown': 0}
df['Housing Binary'] = df['housing'].map(risk_dictionary_binary_class)
df[['housing','Housing Binary']].head(41188)
```

Out[12]:

	housing	Housing Binary
0	no	0
1	no	0
2	yes	1
3	no	0
4	no	0
...	...	...
41183	yes	1
41184	no	0
41185	yes	1
41186	no	0
41187	yes	1

41188 rows × 2 columns

In [13]:
```
df['loan'].value_counts()
```

Out[13]:
```
no         33950
yes         6248
unknown      990
Name: loan, dtype: int64
```

In [14]:
```
risk_dictionary_binary_class = {'yes': 1,'no': 0, 'unknown': 0}
df['Loan Binary'] = df['loan'].map(risk_dictionary_binary_class)
df[['loan','Loan Binary']].head(41188)
```

Out[14]:

	loan	Loan Binary
0	no	0
1	no	0
2	no	0
3	no	0
4	yes	1
...	...	...
41183	no	0
41184	no	0
41185	no	0
41186	no	0
41187	no	0

41188 rows × 2 columns

In [15]:
```
df['poutcome'].value_counts()
```

Out[15]:
```
nonexistent    35563
failure         4252
success         1373
Name: poutcome, dtype: int64
```

In [16]:
```
risk_dictionary_binary_class = {'success': 2,'failure': 0, 'nonexistent': 1}
df['Poutcome Binary'] = df['poutcome'].map(risk_dictionary_binary_class)
df[['poutcome','Poutcome Binary']].head(41188)
```

Out[16]:

	poutcome	Poutcome Binary
0	nonexistent	1
1	nonexistent	1
2	nonexistent	1
3	nonexistent	1
4	nonexistent	1
...	...	...
41183	nonexistent	1
41184	nonexistent	1
41185	nonexistent	1
41186	nonexistent	1
41187	failure	0

41188 rows × 2 columns

Перекодировка целевого столбца 'y' в бинарные значения и удаление исходного столбца 'y':

In [17]:
```
risk_dictionary_binary_class = {'yes': 1, 'no': 0}
df['Target Binary'] = df['y'].map(risk_dictionary_binary_class)
df[['y','Target Binary']].head(41188)
```

Out[17]:

	y	Target Binary
0	no	0
1	no	0
2	no	0
3	no	0
4	no	0
...	...	...
41183	yes	1
41184	no	0
41185	no	0
41186	yes	1
41187	no	0

41188 rows × 2 columns

In [18]:
```
X = df.drop(['y','job','education','marital','education','default','housing','loan'
y = df['Target Binary']
```

In [19]:
```
print(y.isnull().sum())
```

```
0
```

In [20]:
```
X
```

Out[20]:

	age	duration	campaign	pdays	previous	emp.var.rate	cons.price.idx	cons.conf.idx	euri
0	56	261	1	999	0	1.1	93.994	-36.4	
1	57	149	1	999	0	1.1	93.994	-36.4	
2	37	226	1	999	0	1.1	93.994	-36.4	
3	40	151	1	999	0	1.1	93.994	-36.4	
4	56	307	1	999	0	1.1	93.994	-36.4	
...	...	...	...	...	...	...	...	...	
41183	73	334	1	999	0	-1.1	94.767	-50.8	
41184	46	383	1	999	0	-1.1	94.767	-50.8	
41185	56	189	2	999	0	-1.1	94.767	-50.8	
41186	44	442	1	999	0	-1.1	94.767	-50.8	
41187	74	239	3	999	1	-1.1	94.767	-50.8	

41188 rows × 15 columns

Преобразование категориальных данных с помощью и масштабирование данных:

In [33]:
```
min_max_scaler = MinMaxScaler()
X_scaled = min_max_scaler.fit_transform(X)
```

Разделение данных на тренировочный, тестовый и валидационный наборы:

In [34]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, stratify=y, test_size = 0
print(f'Train : {X_train.shape}, Test : {X_test.shape}')
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, stratify=y_trai
print(f'Train : {X_train.shape}, Test : {X_val.shape}')
```

```
Train : (32950, 15), Test : (8238, 15)
Train : (26360, 15), Test : (6590, 15)
```

Обучение модели с использованием Keras. Создание модели нейронной сети, ее компиляция:

In [35]:
```
binary_classifier = Sequential()
binary_classifier.add(Dense(units=4,activation='relu',input_dim=15))
binary_classifier.add(Dense(units=1,activation='sigmoid'))
```

In [36]:
```
binary_classifier.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_2 (Dense)             (None, 4)                 64

 dense_3 (Dense)             (None, 1)                 5

=================================================================
Total params: 69 (276.00 Byte)
Trainable params: 69 (276.00 Byte)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [37]:
```
binary_classifier.compile(loss='binary_crossentropy',optimizer='adam',
                          metrics='accuracy')
```

In [38]:
```
early_stop = EarlyStopping(monitor='val_accuracy',patience=15,mode='max',verbose=1)
checkpoint = ModelCheckpoint('C:/Users/vvadi/DeepLearning/Binary_Classifier-{epoch:
                              monitor='val_accuracy',verbose=1,mode='max',
                              save_best_only=True)
callbacks_list=[early_stop,checkpoint]
```

Обучение модели

In [54]:
```
binary_classifier_history = binary_classifier.fit(X_train, y_train, batch_size=10,
                      validation_data=(X_val,y_val), callbacks=callbacks_list, epoc
```

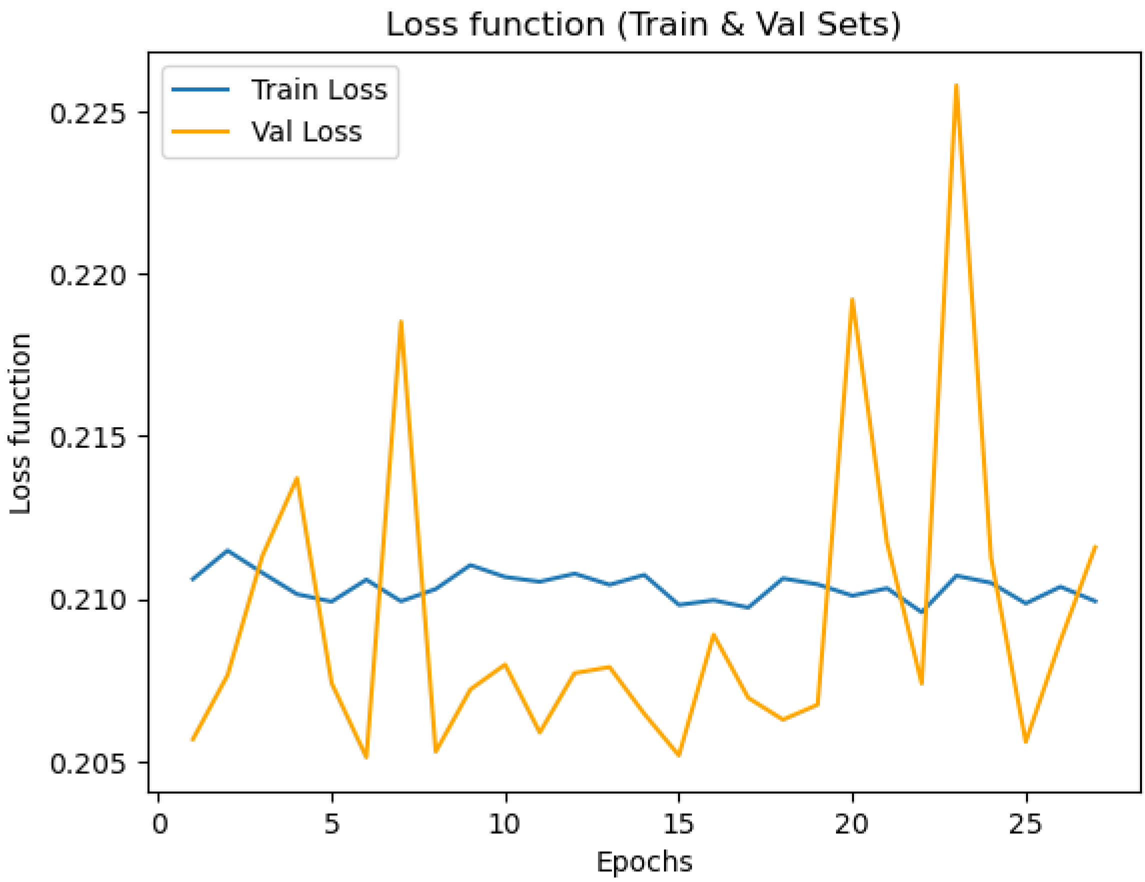
```
Epoch 1/40
2624/2636 [============================>.] - ETA: 0s - loss: 0.2108 - accuracy: 0.
9050
Epoch 1: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2106 - accurac
y: 0.9050 - val_loss: 0.2057 - val_accuracy: 0.9061
Epoch 2/40
2632/2636 [============================>.] - ETA: 0s - loss: 0.2115 - accuracy: 0.
9047
Epoch 2: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2115 - accurac
y: 0.9047 - val_loss: 0.2077 - val_accuracy: 0.9067
Epoch 3/40
2636/2636 [==============================] - ETA: 0s - loss: 0.2108 - accuracy: 0.
9068
Epoch 3: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2108 - accurac
y: 0.9068 - val_loss: 0.2113 - val_accuracy: 0.9036
Epoch 4/40
2631/2636 [============================>.] - ETA: 0s - loss: 0.2101 - accuracy: 0.
9064
Epoch 4: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2102 - accurac
y: 0.9065 - val_loss: 0.2137 - val_accuracy: 0.8947
Epoch 5/40
2624/2636 [============================>.] - ETA: 0s - loss: 0.2094 - accuracy: 0.
9062
Epoch 5: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2099 - accurac
y: 0.9060 - val_loss: 0.2074 - val_accuracy: 0.9055
Epoch 6/40
2629/2636 [============================>.] - ETA: 0s - loss: 0.2106 - accuracy: 0.
9070
Epoch 6: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2106 - accurac
y: 0.9070 - val_loss: 0.2051 - val_accuracy: 0.9055
Epoch 7/40
2629/2636 [============================>.] - ETA: 0s - loss: 0.2096 - accuracy: 0.
9072
Epoch 7: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 13s 5ms/step - loss: 0.2099 - accurac
y: 0.9069 - val_loss: 0.2185 - val_accuracy: 0.8954
Epoch 8/40
2636/2636 [==============================] - ETA: 0s - loss: 0.2103 - accuracy: 0.
9058
Epoch 8: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2103 - accurac
y: 0.9058 - val_loss: 0.2053 - val_accuracy: 0.9041
Epoch 9/40
2628/2636 [============================>.] - ETA: 0s - loss: 0.2111 - accuracy: 0.
9063
Epoch 9: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2110 - accurac
y: 0.9064 - val_loss: 0.2072 - val_accuracy: 0.9067
Epoch 10/40
2625/2636 [============================>.] - ETA: 0s - loss: 0.2107 - accuracy: 0.
9055
Epoch 10: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2107 - accurac
y: 0.9056 - val_loss: 0.2080 - val_accuracy: 0.9067
Epoch 11/40
2631/2636 [============================>.] - ETA: 0s - loss: 0.2106 - accuracy: 0.
9065
Epoch 11: val_accuracy did not improve from 0.90926
```

```
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2105 - accurac
y: 0.9065 - val_loss: 0.2059 - val_accuracy: 0.9070
Epoch 12/40
2629/2636 [============================>.] - ETA: 0s - loss: 0.2110 - accuracy: 0.
9067
Epoch 12: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2108 - accurac
y: 0.9068 - val_loss: 0.2077 - val_accuracy: 0.9076
Epoch 13/40
2630/2636 [============================>.] - ETA: 0s - loss: 0.2103 - accuracy: 0.
9064
Epoch 13: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2104 - accurac
y: 0.9063 - val_loss: 0.2079 - val_accuracy: 0.9024
Epoch 14/40
2633/2636 [============================>.] - ETA: 0s - loss: 0.2106 - accuracy: 0.
9053
Epoch 14: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2107 - accurac
y: 0.9052 - val_loss: 0.2065 - val_accuracy: 0.9071
Epoch 15/40
2630/2636 [============================>.] - ETA: 0s - loss: 0.2098 - accuracy: 0.
9066
Epoch 15: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2098 - accurac
y: 0.9066 - val_loss: 0.2052 - val_accuracy: 0.9067
Epoch 16/40
2626/2636 [============================>.] - ETA: 0s - loss: 0.2101 - accuracy: 0.
9064
Epoch 16: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2100 - accurac
y: 0.9065 - val_loss: 0.2089 - val_accuracy: 0.9032
Epoch 17/40
2634/2636 [============================>.] - ETA: 0s - loss: 0.2097 - accuracy: 0.
9064
Epoch 17: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 13s 5ms/step - loss: 0.2097 - accurac
y: 0.9064 - val_loss: 0.2070 - val_accuracy: 0.9035
Epoch 18/40
2631/2636 [============================>.] - ETA: 0s - loss: 0.2106 - accuracy: 0.
9062
Epoch 18: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 14s 5ms/step - loss: 0.2106 - accurac
y: 0.9061 - val_loss: 0.2063 - val_accuracy: 0.9071
Epoch 19/40
2627/2636 [============================>.] - ETA: 0s - loss: 0.2104 - accuracy: 0.
9061
Epoch 19: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 14s 5ms/step - loss: 0.2105 - accurac
y: 0.9060 - val_loss: 0.2067 - val_accuracy: 0.9074
Epoch 20/40
2635/2636 [============================>.] - ETA: 0s - loss: 0.2100 - accuracy: 0.
9058
Epoch 20: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 17s 7ms/step - loss: 0.2101 - accurac
y: 0.9058 - val_loss: 0.2192 - val_accuracy: 0.8933
Epoch 21/40
2632/2636 [============================>.] - ETA: 0s - loss: 0.2103 - accuracy: 0.
9071
Epoch 21: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 16s 6ms/step - loss: 0.2103 - accurac
y: 0.9071 - val_loss: 0.2117 - val_accuracy: 0.9009
Epoch 22/40
2631/2636 [============================>.] - ETA: 0s - loss: 0.2096 - accuracy: 0.
```

```
9064
Epoch 22: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 15s 6ms/step - loss: 0.2096 - accurac
y: 0.9064 - val_loss: 0.2074 - val_accuracy: 0.9062
Epoch 23/40
2636/2636 [==============================] - ETA: 0s - loss: 0.2107 - accuracy: 0.
9060
Epoch 23: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2107 - accurac
y: 0.9060 - val_loss: 0.2258 - val_accuracy: 0.9070
Epoch 24/40
2634/2636 [============================>.] - ETA: 0s - loss: 0.2105 - accuracy: 0.
9063
Epoch 24: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 4ms/step - loss: 0.2105 - accurac
y: 0.9063 - val_loss: 0.2113 - val_accuracy: 0.9074
Epoch 25/40
2627/2636 [============================>.] - ETA: 0s - loss: 0.2098 - accuracy: 0.
9061
Epoch 25: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2099 - accurac
y: 0.9060 - val_loss: 0.2056 - val_accuracy: 0.9067
Epoch 26/40
2633/2636 [============================>.] - ETA: 0s - loss: 0.2103 - accuracy: 0.
9054
Epoch 26: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2104 - accurac
y: 0.9053 - val_loss: 0.2087 - val_accuracy: 0.9002
Epoch 27/40
2624/2636 [============================>.] - ETA: 0s - loss: 0.2097 - accuracy: 0.
9060
Epoch 27: val_accuracy did not improve from 0.90926
2636/2636 [==============================] - 12s 5ms/step - loss: 0.2099 - accurac
y: 0.9060 - val_loss: 0.2116 - val_accuracy: 0.9058
Epoch 27: early stopping
```

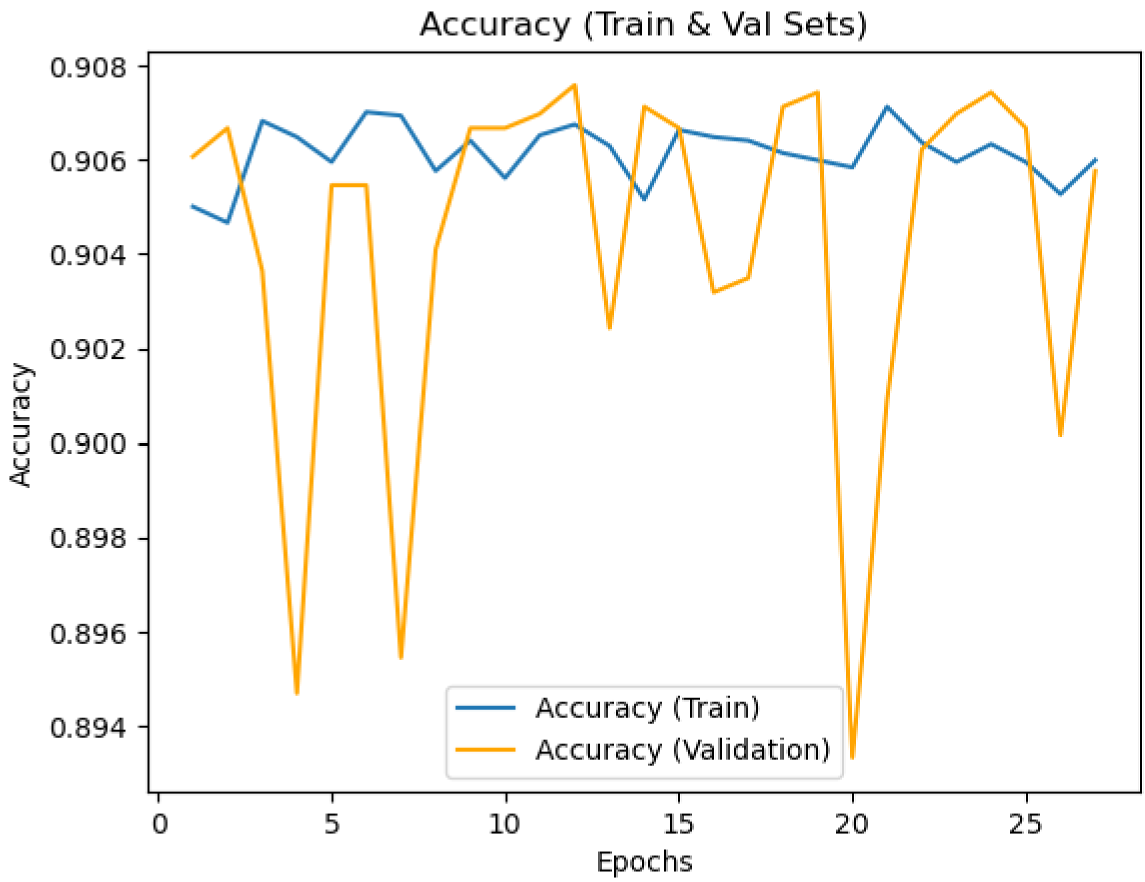
Построение графика потери

In [55]:
```python
loss_function = binary_classifier_history.history['loss']
val_loss_function = binary_classifier_history.history['val_loss']
epochs = range(1,len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs,loss_function,label='Train Loss')
plt.plot(epochs,val_loss_function,color='orange',label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```



Построение графика точности в процессе обучения

In [56]:
```
acc = binary_classifier_history.history['accuracy']
val_acc = binary_classifier_history.history['val_accuracy']
epochs = range(1,len(acc)+1)

plt.title('Accuracy (Train & Val Sets)')
plt.plot(epochs,acc,label='Accuracy (Train)')
plt.plot(epochs,val_acc,color='orange',label='Accuracy (Validation)')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



Тестирование модели на тестовых данных и предсказание класса для конкретного образца:

In [57]:
```
# Load a saved model
#from keras.models import load_model
#saved_model = load_model('best_model.h5')
binary_classifier.load_weights('C:/Users/vvadi/DeepLearning/Binary_Classifier-19-0.
```

In [58]:
```
results = binary_classifier.evaluate(X_test,y_test)
```

```
258/258 [==============================] - 1s 3ms/step - loss: 0.2158 - accuracy:
0.9093
```

In [59]:
```
#x_test_pattern = X_test[1,:]
#y_pred = binary_classifier.predict(x_test_pattern.reshape(1,-1))
x_test_pattern = X_test.iloc[1]
x_test_pattern = x_test_pattern.values.reshape(1,-1)
y_pred = binary_classifier.predict(x_test_pattern)
print(y_pred[0])
```

```
1/1 [==============================] - 0s 50ms/step
[0.00019114]
```

In [60]:
```
y_test
```

Out[60]:
```
17589    0
3158     0
2118     0
12435    0
13939    0
        ..
33427    0
32280    0
25947    0
13050    0
39975    1
Name: Target Binary, Length: 8238, dtype: int64
```

In [61]:
```
print(x_test_pattern)
```

```
[[ 5.2000e+01  3.6000e+01  1.0000e+00  9.9900e+02  0.0000e+00  1.1000e+00
   9.3994e+01 -3.6400e+01  4.8600e+00  5.1910e+03  1.0000e+00  0.0000e+00
   1.0000e+00  0.0000e+00  1.0000e+00]]
```

Возврат особенностей тестового набора данных к их исходному масштабу:

In [62]:
```
original_features= min_max_scaler.inverse_transform(x_test_pattern.reshape(1,-1))
original_features
```

Out[62]:
```
array([[ 4.22900000e+03,  1.77048000e+05,  5.60000000e+01,
         9.98001000e+05,  0.00000000e+00,  1.88000000e+00,
         3.33389604e+02, -9.20760000e+02,  2.20714600e+01,
         1.37798310e+06,  1.00000000e+00,  0.00000000e+00,
         1.00000000e+00,  0.00000000e+00,  2.00000000e+00]])
```

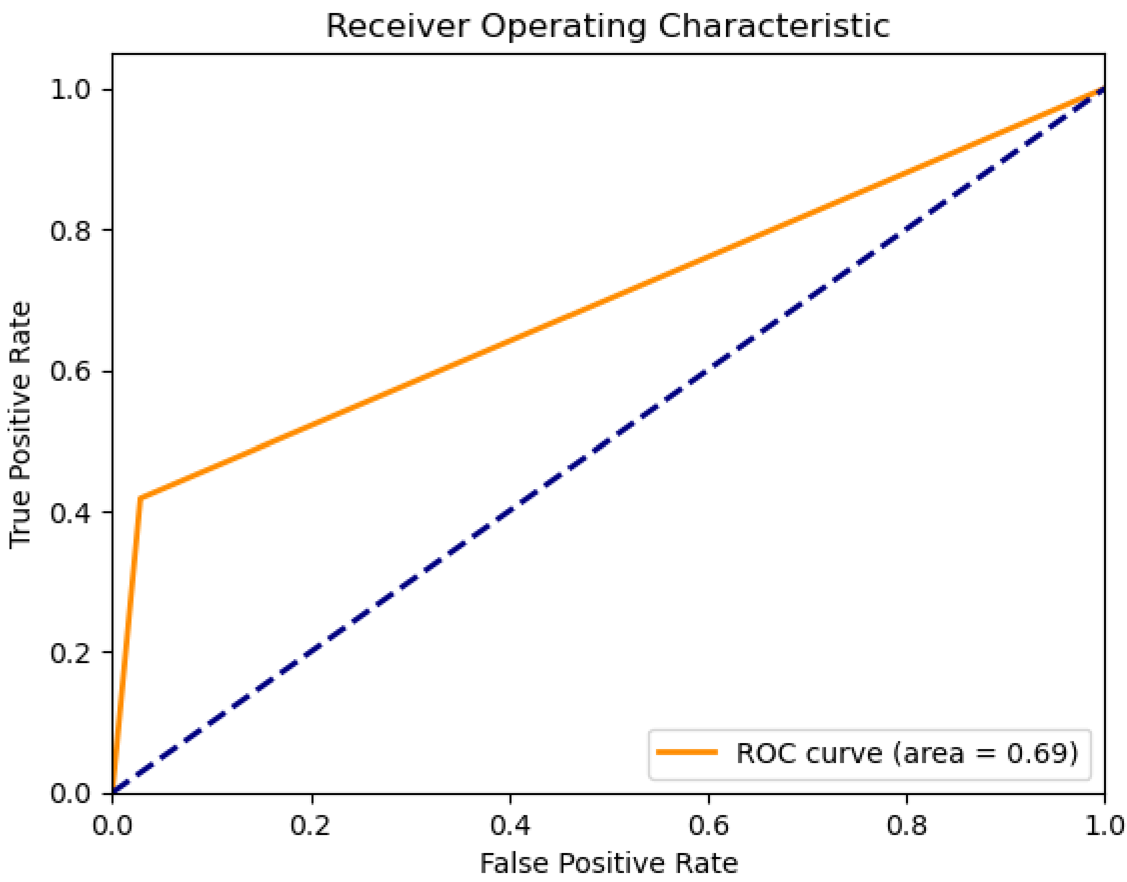
Метрики работы Recall, Precision, Weighted Accuracy, AUC

In [63]:
```
from sklearn.metrics import recall_score, precision_score, roc_auc_score, confusion

# Делаем предсказания
y_pred = binary_classifier.predict(X_test)
#y_pred = np.round(y_pred)
y_pred = (y_pred > 0.5).astype(int).reshape(y_test.shape)


# Вычисляем метрики
recall = recall_score(y_test, y_pred)
precision = precision_score(y_test, y_pred)
auc = roc_auc_score(y_test, y_pred)

# Вычисляем accuracy для каждого класса и получаем средневзвешенное значение
cm = confusion_matrix(y_test, y_pred)
class_wise = cm.diagonal()/cm.sum(axis=1)
weighted_accuracy = np.average(class_wise, weights=cm.sum(axis=1))

print(f"Recall: {recall}\nPrecision: {precision}\nAUC: {auc}\nWeighted Accuracy: {w
```

```
258/258 [==============================] - 1s 3ms/step
Recall: 0.41810344827586204
Precision: 0.6521008403361345
AUC: 0.6948930374074249
Weighted Accuracy: 0.9093226511289147
```

Расчет значений для ROC-кривой и AUC

In [64]:
```
# Расчет значений для ROC-кривой и AUC
fpr, tpr, _ = roc_curve(y_test, y_pred)

# Построение ROC-кривой
plt.figure()
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' % auc
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")

# Отображение ROC-кривой
plt.show()

# Отображение метрик в виде датафрейма
metrics_df = pd.DataFrame(data={"Recall": [recall], "Precision": [precision], "AUC'
print(metrics_df.head())
```




```
     Recall  Precision       AUC  Weighted Accuracy
0  0.418103   0.652101  0.694893           0.909323
```

In [ ]:

Лабораторная работа № 1

Боровских Вадим, 932003

B) Многоклассовый классификатор fetal_health.csv

In [21]:
```
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from keras.models import Sequential
from keras.layers import Dense
from keras.callbacks import ModelCheckpoint, EarlyStopping
```

In [22]:
```
df = pd.read_csv("fetal_health.csv", quotechar='"', index_col = 0)
df=df.reset_index()
df
```

Out[22]:

	baseline value	accelerations	fetal_movement	uterine_contractions	light_decelerations	severe_dec
0	120.0	0.000	0.000	0.000	0.000	
1	132.0	0.006	0.000	0.006	0.003	
2	133.0	0.003	0.000	0.008	0.003	
3	134.0	0.003	0.000	0.008	0.003	
4	132.0	0.007	0.000	0.008	0.000	
...	...	...	...	...	...	
2121	140.0	0.000	0.000	0.007	0.000	
2122	140.0	0.001	0.000	0.007	0.000	
2123	140.0	0.001	0.000	0.007	0.000	
2124	140.0	0.001	0.000	0.006	0.000	
2125	142.0	0.002	0.002	0.008	0.000	

2126 rows × 22 columns

In [23]:
```
df.columns
```

Out[23]:
```
Index(['baseline value', 'accelerations', 'fetal_movement',
       'uterine_contractions', 'light_decelerations', 'severe_decelerations',
       'prolongued_decelerations', 'abnormal_short_term_variability',
       'mean_value_of_short_term_variability',
       'percentage_of_time_with_abnormal_long_term_variability',
       'mean_value_of_long_term_variability', 'histogram_width',
       'histogram_min', 'histogram_max', 'histogram_number_of_peaks',
       'histogram_number_of_zeroes', 'histogram_mode', 'histogram_mean',
       'histogram_median', 'histogram_variance', 'histogram_tendency',
       'fetal_health'],
      dtype='object')
```

In [24]:
```
df['fetal_health'].unique()
```

Out[24]:
```
array([2., 1., 3.])
```

In [25]:
```
df['fetal_health'].value_counts()
```

Out[25]:
```
1.0    1655
2.0     295
3.0     176
Name: fetal_health, dtype: int64
```

1 - соответствует нормальному состоянию плода, 2 - подозрительному состоянию плода,3 - патология

In [26]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2126 entries, 0 to 2125
Data columns (total 22 columns):
 #   Column                                                  Non-Null Count  Dtype
---  ------                                                  --------------  -----
 0   baseline value                                          2126 non-null   float
64
 1   accelerations                                           2126 non-null   float
64
 2   fetal_movement                                          2126 non-null   float
64
 3   uterine_contractions                                    2126 non-null   float
64
 4   light_decelerations                                     2126 non-null   float
64
 5   severe_decelerations                                    2126 non-null   float
64
 6   prolongued_decelerations                                2126 non-null   float
64
 7   abnormal_short_term_variability                         2126 non-null   float
64
 8   mean_value_of_short_term_variability                    2126 non-null   float
64
 9   percentage_of_time_with_abnormal_long_term_variability  2126 non-null   float
64
 10  mean_value_of_long_term_variability                     2126 non-null   float
64
 11  histogram_width                                         2126 non-null   float
64
 12  histogram_min                                           2126 non-null   float
64
 13  histogram_max                                           2126 non-null   float
64
 14  histogram_number_of_peaks                               2126 non-null   float
64
 15  histogram_number_of_zeroes                              2126 non-null   float
64
 16  histogram_mode                                          2126 non-null   float
64
 17  histogram_mean                                          2126 non-null   float
64
 18  histogram_median                                        2126 non-null   float
64
 19  histogram_variance                                      2126 non-null   float
64
 20  histogram_tendency                                      2126 non-null   float
64
 21  fetal_health                                            2126 non-null   float
64
dtypes: float64(22)
memory usage: 365.5 KB
```

In [27]:
```
risk_dictionary_multi_class = {2:2, 1:1, 3:3}

df['Target Multi'] = df['fetal_health'].map(risk_dictionary_multi_class)
```

In [28]:
```
df[['fetal_health','Target Multi']].head()
```

Out[28]:

	fetal_health	Target Multi
0	2.0	2
1	1.0	1
2	1.0	1
3	1.0	1
4	1.0	1

In [29]:
```
Xmc = df.drop(['fetal_health','Target Multi'],axis=1)
y = df['Target Multi']
y
```

Out[29]:
```
0       2
1       1
2       1
3       1
4       1
       ..
2121    2
2122    2
2123    2
2124    2
2125    1
Name: Target Multi, Length: 2126, dtype: int64
```

In [30]:
```
print(y.isnull().sum())
```

```
0
```

Преобразование категориальных данных с помощью get_dummies и масштабирование данных:

In [31]:
```
from sklearn.preprocessing import MinMaxScaler
min_max_scaler = MinMaxScaler()
Xmc = min_max_scaler.fit_transform(Xmc)
```

In [32]:
```
from sklearn.model_selection import train_test_split
X_all_train, X_test, y_all_train, y_test = train_test_split(Xmc, y, stratify=y, tes
print(f'Train : {X_all_train.shape}, Test : {X_test.shape}')
```

```
Train : (1700, 21), Test : (426, 21)
```

In [33]:
```
X_train, X_val, y_train, y_val = train_test_split(X_all_train, y_all_train, stratif
print(f'Train : {X_train.shape}, Test : {X_val.shape}')
```

```
Train : (1360, 21), Test : (340, 21)
```

In [34]:
```
from tensorflow.keras.utils import to_categorical
y_train = to_categorical(y_train)
y_val = to_categorical(y_val)
y_test = to_categorical(y_test)
print('y_train shape:', y_train.shape)
print('y_val shape:', y_val.shape)
print('y_test shape:', y_test.shape)
```

```
y_train shape: (1360, 4)
y_val shape: (340, 4)
y_test shape: (426, 4)
```

In [35]:
```
multi_classifier = Sequential()
multi_classifier.add(Dense(8,activation='relu',input_dim=21))
multi_classifier.add(Dense(4,activation='softmax'))
```

In [36]:
```
multi_classifier.compile(loss='categorical_crossentropy',optimizer='adam',
                          metrics='accuracy')

early_stop = EarlyStopping(monitor='val_accuracy',patience=15,mode='max',verbose=1)
checkpoint = ModelCheckpoint('C:/Users/vvadi/DeepLearning/multi_classifier-{epoch:0
                              monitor='val_accuracy',verbose=1,mode='max',
                              save_best_only=True)
callbacks_list=[early_stop,checkpoint]
```

In [37]:
```
multi_classifier_history = multi_classifier.fit(X_train, y_train, batch_size=20,
                      validation_data=(X_val,y_val), epochs=50)
```

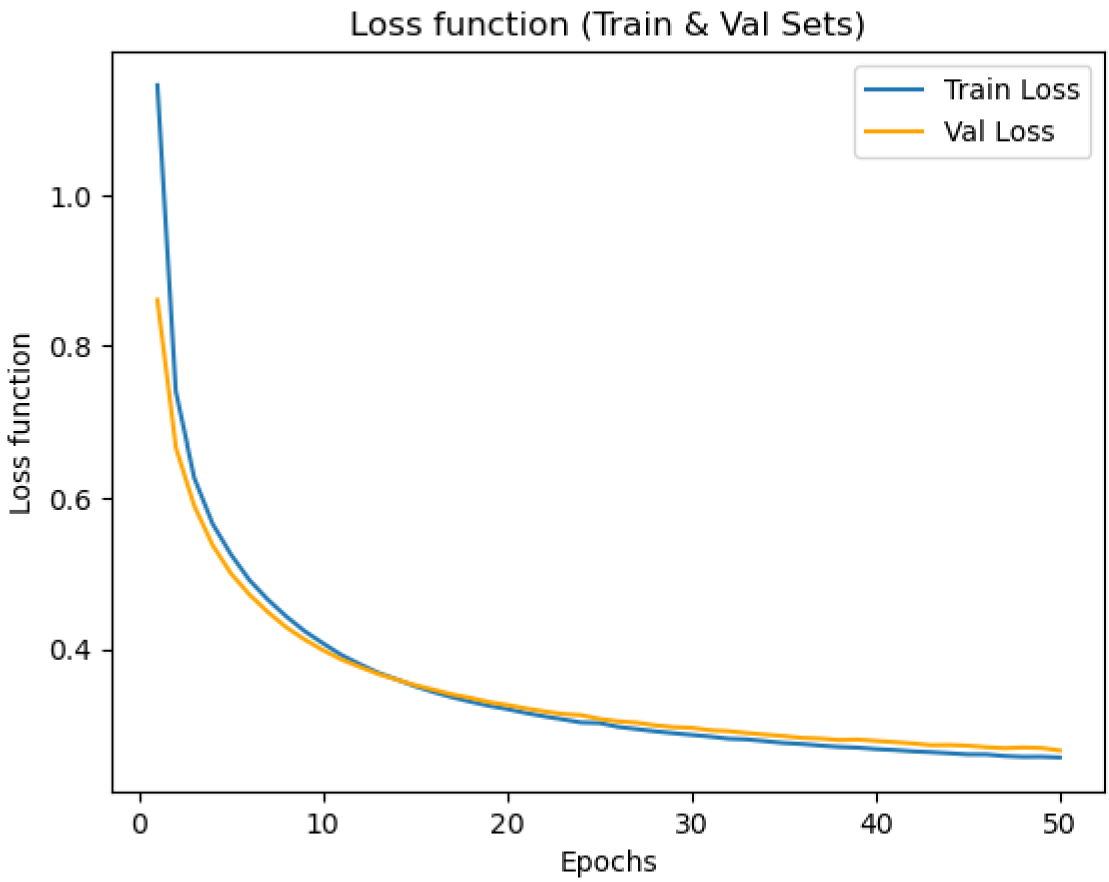
```
Epoch 1/50
68/68 [==============================] - 2s 12ms/step - loss: 1.1452 - accuracy:
0.5529 - val_loss: 0.8608 - val_accuracy: 0.7824
Epoch 2/50
68/68 [==============================] - 0s 5ms/step - loss: 0.7402 - accuracy: 0.
7801 - val_loss: 0.6669 - val_accuracy: 0.7794
Epoch 3/50
68/68 [==============================] - 0s 5ms/step - loss: 0.6268 - accuracy: 0.
7794 - val_loss: 0.5896 - val_accuracy: 0.7882
Epoch 4/50
68/68 [==============================] - 0s 5ms/step - loss: 0.5657 - accuracy: 0.
7824 - val_loss: 0.5375 - val_accuracy: 0.7853
Epoch 5/50
68/68 [==============================] - 0s 6ms/step - loss: 0.5250 - accuracy: 0.
7860 - val_loss: 0.4998 - val_accuracy: 0.7912
Epoch 6/50
68/68 [==============================] - 0s 5ms/step - loss: 0.4913 - accuracy: 0.
7956 - val_loss: 0.4721 - val_accuracy: 0.7882
Epoch 7/50
68/68 [==============================] - 0s 5ms/step - loss: 0.4654 - accuracy: 0.
8081 - val_loss: 0.4489 - val_accuracy: 0.8176
Epoch 8/50
68/68 [==============================] - 0s 5ms/step - loss: 0.4431 - accuracy: 0.
8206 - val_loss: 0.4288 - val_accuracy: 0.8265
Epoch 9/50
68/68 [==============================] - 0s 6ms/step - loss: 0.4236 - accuracy: 0.
8250 - val_loss: 0.4125 - val_accuracy: 0.8294
Epoch 10/50
68/68 [==============================] - 0s 6ms/step - loss: 0.4075 - accuracy: 0.
8360 - val_loss: 0.3983 - val_accuracy: 0.8265
Epoch 11/50
68/68 [==============================] - 0s 6ms/step - loss: 0.3920 - accuracy: 0.
8434 - val_loss: 0.3860 - val_accuracy: 0.8324
Epoch 12/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3798 - accuracy: 0.
8463 - val_loss: 0.3762 - val_accuracy: 0.8382
Epoch 13/50
68/68 [==============================] - 0s 6ms/step - loss: 0.3684 - accuracy: 0.
8507 - val_loss: 0.3669 - val_accuracy: 0.8382
Epoch 14/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3597 - accuracy: 0.
8507 - val_loss: 0.3594 - val_accuracy: 0.8412
Epoch 15/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3506 - accuracy: 0.
8596 - val_loss: 0.3521 - val_accuracy: 0.8441
Epoch 16/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3429 - accuracy: 0.
8559 - val_loss: 0.3461 - val_accuracy: 0.8441
Epoch 17/50
68/68 [==============================] - 0s 6ms/step - loss: 0.3361 - accuracy: 0.
8551 - val_loss: 0.3400 - val_accuracy: 0.8559
Epoch 18/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3302 - accuracy: 0.
8632 - val_loss: 0.3353 - val_accuracy: 0.8441
Epoch 19/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3248 - accuracy: 0.
8551 - val_loss: 0.3297 - val_accuracy: 0.8588
Epoch 20/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3204 - accuracy: 0.
8581 - val_loss: 0.3258 - val_accuracy: 0.8588
Epoch 21/50
68/68 [==============================] - 0s 6ms/step - loss: 0.3153 - accuracy: 0.
8618 - val_loss: 0.3213 - val_accuracy: 0.8618
Epoch 22/50
```

```
68/68 [==============================] - 0s 5ms/step - loss: 0.3108 - accuracy: 0.
8654 - val_loss: 0.3174 - val_accuracy: 0.8618
Epoch 23/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3067 - accuracy: 0.
8632 - val_loss: 0.3139 - val_accuracy: 0.8588
Epoch 24/50
68/68 [==============================] - 0s 5ms/step - loss: 0.3026 - accuracy: 0.
8669 - val_loss: 0.3123 - val_accuracy: 0.8588
Epoch 25/50
68/68 [==============================] - 0s 6ms/step - loss: 0.3019 - accuracy: 0.
8647 - val_loss: 0.3073 - val_accuracy: 0.8588
Epoch 26/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2968 - accuracy: 0.
8640 - val_loss: 0.3042 - val_accuracy: 0.8618
Epoch 27/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2939 - accuracy: 0.
8684 - val_loss: 0.3024 - val_accuracy: 0.8618
Epoch 28/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2910 - accuracy: 0.
8676 - val_loss: 0.2989 - val_accuracy: 0.8735
Epoch 29/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2884 - accuracy: 0.
8728 - val_loss: 0.2965 - val_accuracy: 0.8735
Epoch 30/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2862 - accuracy: 0.
8757 - val_loss: 0.2956 - val_accuracy: 0.8647
Epoch 31/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2839 - accuracy: 0.
8757 - val_loss: 0.2924 - val_accuracy: 0.8765
Epoch 32/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2811 - accuracy: 0.
8772 - val_loss: 0.2911 - val_accuracy: 0.8765
Epoch 33/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2802 - accuracy: 0.
8787 - val_loss: 0.2887 - val_accuracy: 0.8765
Epoch 34/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2779 - accuracy: 0.
8779 - val_loss: 0.2866 - val_accuracy: 0.8824
Epoch 35/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2755 - accuracy: 0.
8801 - val_loss: 0.2846 - val_accuracy: 0.8765
Epoch 36/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2741 - accuracy: 0.
8801 - val_loss: 0.2822 - val_accuracy: 0.8824
Epoch 37/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2720 - accuracy: 0.
8824 - val_loss: 0.2814 - val_accuracy: 0.8912
Epoch 38/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2703 - accuracy: 0.
8824 - val_loss: 0.2793 - val_accuracy: 0.8912
Epoch 39/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2694 - accuracy: 0.
8846 - val_loss: 0.2800 - val_accuracy: 0.8706
Epoch 40/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2675 - accuracy: 0.
8824 - val_loss: 0.2783 - val_accuracy: 0.8941
Epoch 41/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2662 - accuracy: 0.
8831 - val_loss: 0.2766 - val_accuracy: 0.8941
Epoch 42/50
68/68 [==============================] - 0s 7ms/step - loss: 0.2644 - accuracy: 0.
8838 - val_loss: 0.2749 - val_accuracy: 0.8971
Epoch 43/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2633 - accuracy: 0.
```

```
8846 - val_loss: 0.2726 - val_accuracy: 0.8853
Epoch 44/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2619 - accuracy: 0.
8868 - val_loss: 0.2728 - val_accuracy: 0.8941
Epoch 45/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2604 - accuracy: 0.
8882 - val_loss: 0.2719 - val_accuracy: 0.8941
Epoch 46/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2603 - accuracy: 0.
8868 - val_loss: 0.2699 - val_accuracy: 0.8941
Epoch 47/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2582 - accuracy: 0.
8912 - val_loss: 0.2686 - val_accuracy: 0.8882
Epoch 48/50
68/68 [==============================] - 0s 6ms/step - loss: 0.2571 - accuracy: 0.
8875 - val_loss: 0.2695 - val_accuracy: 0.8971
Epoch 49/50
68/68 [==============================] - 1s 8ms/step - loss: 0.2572 - accuracy: 0.
8897 - val_loss: 0.2688 - val_accuracy: 0.8941
Epoch 50/50
68/68 [==============================] - 0s 5ms/step - loss: 0.2563 - accuracy: 0.
8890 - val_loss: 0.2656 - val_accuracy: 0.8882
```

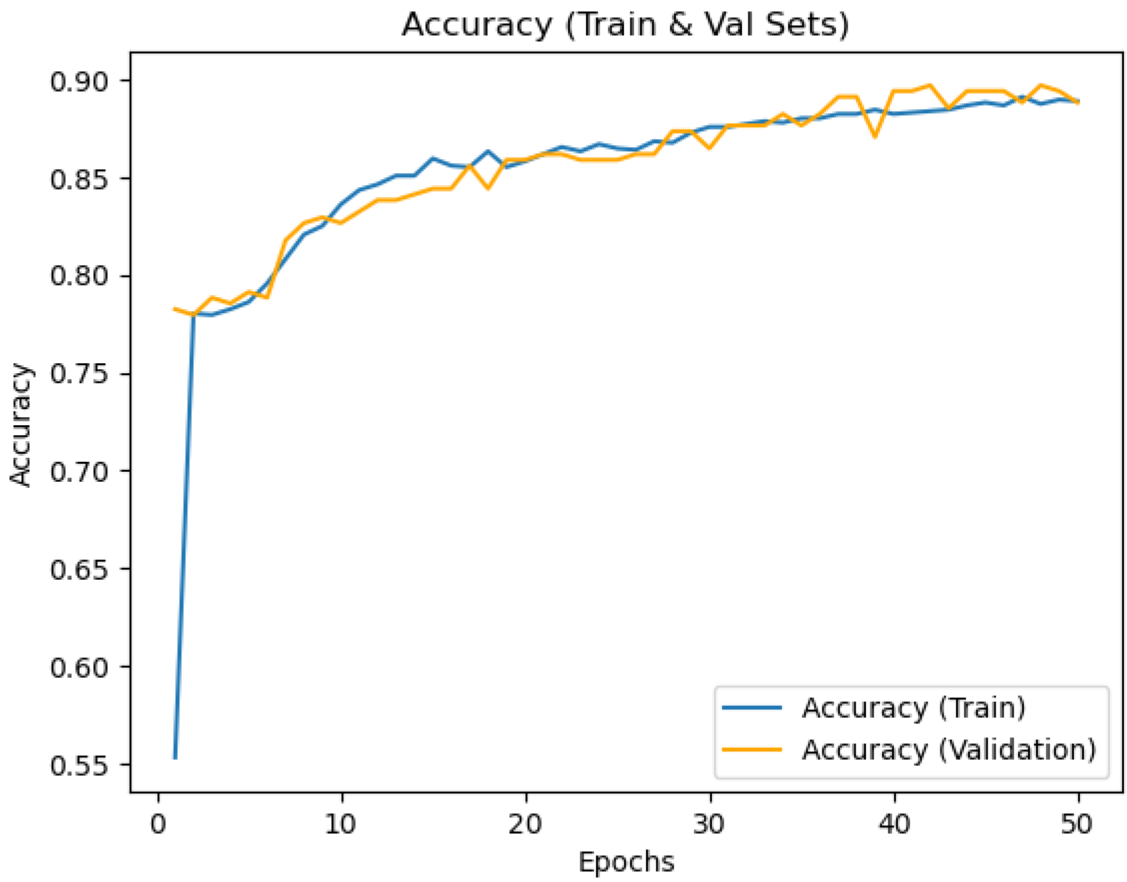
Построение графика потери

In [38]:
```
loss_function = multi_classifier_history.history['loss']
val_loss_function = multi_classifier_history.history['val_loss']
epochs = range(1,len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs,loss_function,label='Train Loss')
plt.plot(epochs,val_loss_function,color='orange',label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```



Построение графика точности

In [39]:
```
acc = multi_classifier_history.history['accuracy']
val_acc = multi_classifier_history.history['val_accuracy']
epochs = range(1,len(acc)+1)

plt.title('Accuracy (Train & Val Sets)')
plt.plot(epochs,acc,label='Accuracy (Train)')
plt.plot(epochs,val_acc,color='orange',label='Accuracy (Validation)')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



In [40]:
```
print(y_test[4])
```

```
[0. 1. 0. 0.]
```

In [50]:
```
x_test_pattern = X_test[4,:]
original_features= min_max_scaler.inverse_transform(x_test_pattern.reshape(1,-1))
print(original_features)

y_pred = multi_classifier.predict(x_test_pattern.reshape(1,-1))
```

```
[[1.52e+02 0.00e+00 0.00e+00 5.00e-03 0.00e+00 0.00e+00 0.00e+00 6.20e+01
  4.00e-01 5.90e+01 5.60e+00 2.50e+01 1.36e+02 1.61e+02 0.00e+00 0.00e+00
  1.59e+02 1.56e+02 1.58e+02 1.00e+00 1.00e+00]]
1/1 [==============================] - 0s 58ms/step
```

In [51]:
```
from sklearn.preprocessing import label_binarize
import numpy as np

y_bin = label_binarize(y, classes=np.unique(y))
n_classes = y_bin.shape[1]
```

In [52]:
```
X = Xmc
X_train, X_test, y_train, y_test = train_test_split(X, y_bin, test_size=.2, random_
print('Shape of X:', X.shape)
print('Shape of y_bin:', y_bin.shape)
```

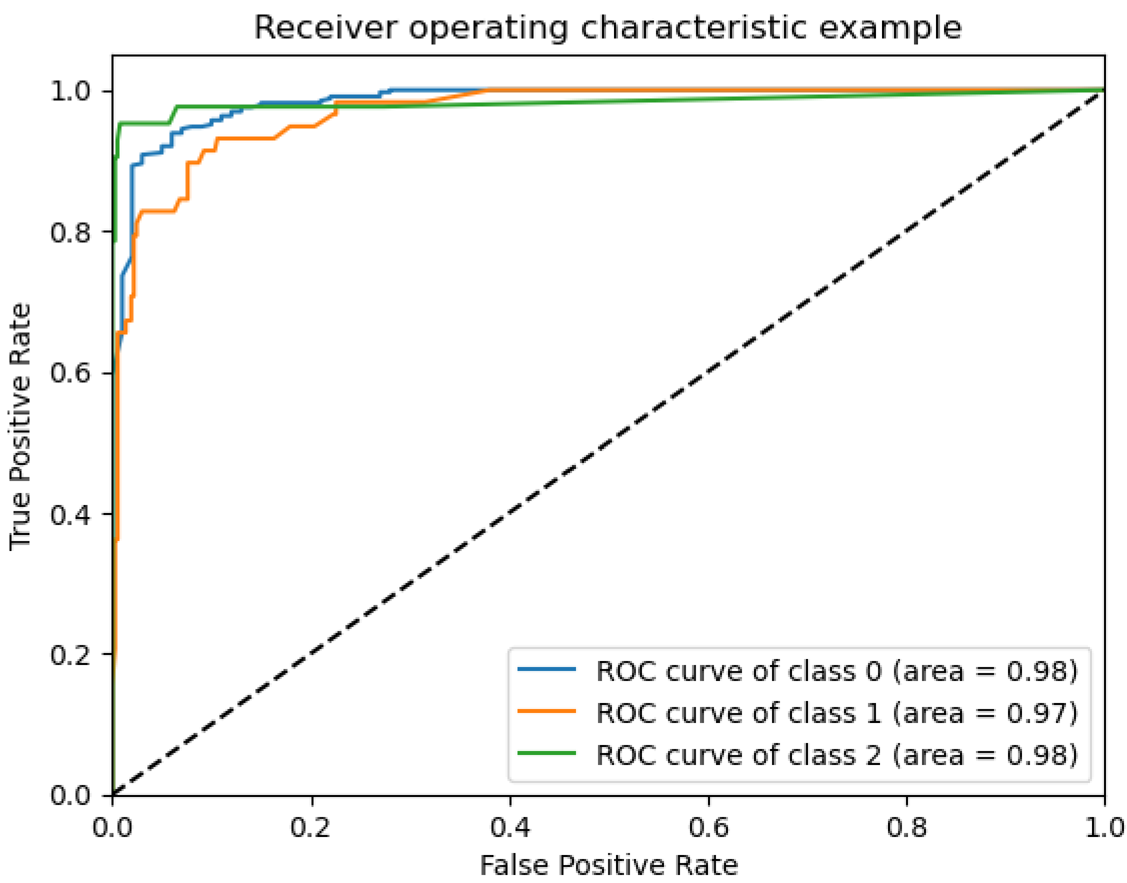
```
Shape of X: (2126, 21)
Shape of y_bin: (2126, 3)
```

Построение ROC-кривой

In [53]:
```
from sklearn.multiclass import OneVsRestClassifier
from sklearn.ensemble import RandomForestClassifier
```

```
classifier = OneVsRestClassifier(RandomForestClassifier())
y_score = classifier.fit(X_train, y_train).predict_proba(X_test)
```

In [54]:
```
from sklearn.metrics import roc_curve, auc

fpr = dict()
tpr = dict()
roc_auc = dict()

for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test[:, i], y_score[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])


# Plot ROC кривые
plt.figure()
for i in range(n_classes):
    plt.plot(fpr[i], tpr[i], label='ROC curve of class {0} (area = {1:0.2f})'.forma

# Добавление случайной диагонали
plt.plot([0, 1], [0, 1], 'k--')

plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic example')
plt.legend(loc="lower right")
plt.show()
```



Метрики работы Recall, Precision, Weighted Accuracy, AUC

In [56]:
```
from sklearn.metrics import precision_recall_fscore_support
```

```
classifier = OneVsRestClassifier(RandomForestClassifier())
y_score = classifier.fit(X_train, y_train).predict_proba(X_test)

y_pred = (y_score == y_score.max(axis=1)[:,None]).astype(int)

precision, recall, _, _ = precision_recall_fscore_support(y_test, y_pred, average='

auc = roc_auc_score(y_test, y_score, multi_class='ovr')

print("Precision: ", precision)
print("Recall: ", recall)
print("AUC: ", auc)

accuracy = accuracy_score(y_test, y_pred)
print("Weighted Accuracy: ", accuracy)
```

```
Precision:  0.9424434917086499
Recall:  0.9436619718309859
AUC:  0.9793782735877897
Weighted Accuracy:  0.9436619718309859
```

In [ ]:

Лабораторная работа № 1

Боровских Вадим, 932003

C) Регрессор DS_2019_public.csv

In [2]:
```
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import accuracy_score
from sklearn.ensemble import RandomForestClassifier
```

In [3]:
```
df = pd.read_csv("DS_2019_public.csv", index_col=0, encoding='cp1252', dtype={col:
df=df.reset_index()
df
```

Out[3]:

	Climate_Region_Pub	DIVISION	REPORTABLE_DOMAIN	DOLELCOL	TOTALDOLCOL	KWHCO
0	5	10	26	16.793	17	181.99
1	1	1	1	48.901	49	184.45
2	1	3	7	101.048	101	1063.02
3	1	1	1	0	0	0.00
4	1	4	10	45.132	45	274.53
...	...	...	...	...	...	.
10870	4	5	13	345.8	346	2695.62
10871	1	3	9	13.005	13	97.49
10872	1	4	10	97.67	98	847.73
10873	1	8	23	12.834	13	135.68
10874	5	10	26	0	0	0.00

10875 rows × 121 columns

In [4]:
```
df.columns
```

Out[4]:
```
Index(['Climate_Region_Pub', 'DIVISION', 'REPORTABLE_DOMAIN', 'DOLELCOL',
       'TOTALDOLCOL', 'KWHCOL', 'BTUELCOL', 'TOTALBTUCOL', 'TOTALDOLSPH',
       'TOTALBTUSPH',
       ...
       'LGT1EE', 'TOTALBTUWTH', 'ROOFTYPE', 'DOLELRFG', 'TOTALDOLRFG',
       'HEATROOM', 'WDWATER', 'UGWARM', 'DRYRFUEL', 'KWHRFG'],
      dtype='object', length=121)
```

In [6]:
```
df.dtypes
```

Out[6]:
```
Climate_Region_Pub      int64
DIVISION                int64
REPORTABLE_DOMAIN       int64
DOLELCOL               object
TOTALDOLCOL             int64
                        ...
HEATROOM                int64
WDWATER                 int64
UGWARM                  int64
DRYRFUEL                int64
KWHRFG                float64
Length: 121, dtype: object
```

In [6]:
```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10875 entries, 0 to 10874
Columns: 121 entries, Climate_Region_Pub to KWHRFG
dtypes: float64(34), int64(79), object(8)
memory usage: 10.0+ MB
```

In [7]:
```python
df.describe()
```

Out[7]:

	Climate_Region_Pub	DIVISION	REPORTABLE_DOMAIN	TOTALDOLCOL	KWHCOL	
count	10875.000000	10875.000000	10875.000000	10875.000000	10875.000000	1
mean	2.601195	5.371034	14.778391	202.429333	1682.782696	
std	1.349507	2.862200	8.207299	310.691148	2480.831034	
min	1.000000	1.000000	1.000000	0.000000	0.000000	
25%	1.000000	3.000000	8.000000	18.000000	143.161500	
50%	3.000000	5.000000	15.000000	90.000000	748.220000	
75%	4.000000	7.000000	21.000000	263.000000	2281.322500	
max	5.000000	10.000000	27.000000	7729.000000	60995.431000	20

8 rows × 113 columns

In [11]:
```python
from sklearn.preprocessing import MinMaxScaler
# Удалите строки с некорректными значениями
df = df[~df.apply(lambda row: row.astype(str).str.contains('[^0-9.]').any(), axis=1
# Затем выполните масштабирование
X = df.drop(['TOTALBTUCOL'], axis=1)
y = df['TOTALBTUCOL']
min_max_scaler = MinMaxScaler()
X = min_max_scaler.fit_transform(X)
```

Разделение данных на обучающую и тестовую выборки

In [12]:
```python
X_train_val, X_test, y_train_val, y_test = train_test_split(X, y, test_size=0.2, ra
X_train, X_val, y_train, y_val = train_test_split(X_train_val, y_train_val, test_si
print(f'Train : {X_train_val.shape}, Test : {X_test.shape}')
print(f'Train : {X_train.shape}, Test : {X_val.shape}')
```

```
Train : (3976, 120), Test : (995, 120)
Train : (3180, 120), Test : (796, 120)
```

Построение модели

In [15]:
```
from keras.models import Sequential
from keras.layers import Dense
regressor = Sequential()
regressor.add(Dense(120, activation='relu', input_dim=X_train.shape[1]))
regressor.add(Dense(60,activation='relu'))
regressor.add(Dense(1,activation='linear'))
regressor.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 120)               14520

 dense_1 (Dense)             (None, 60)                7260

 dense_2 (Dense)             (None, 1)                 61

=================================================================
Total params: 21841 (85.32 KB)
Trainable params: 21841 (85.32 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [16]:
```
regressor.compile(loss='mse', optimizer='adam', metrics='mae')
```

In [19]:
```
from keras.callbacks import ModelCheckpoint, EarlyStopping
early_stop = EarlyStopping(monitor='val_loss', patience=20, mode='min', verbose=1)
checkpoint = ModelCheckpoint('regressor_weights-{epoch:02d}-{val_loss:.3f}.hdf5',
monitor='val_loss', verbose=1, mode='min', save_best_only=True)
callbacks_list = [early_stop, checkpoint]
```

Обучение модели

In [30]:
```
regressor_history = regressor.fit(X_train, y_train, batch_size=40, validation_data=
callbacks=callbacks_list, epochs=350)
```

```
Epoch 1/350
71/80 [=========================>....] - ETA: 0s - loss: 73595.1016 - mae: 177.568
5
Epoch 1: val_loss improved from 91159.12500 to 88805.09375, saving model to regres
sor_weights-01-88805.094.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 79100.7031 - mae: 17
8.3285 - val_loss: 88805.0938 - val_mae: 185.0776
Epoch 2/350
36/80 [============>.................] - ETA: 0s - loss: 83602.2031 - mae: 185.729
1
```

```
D:\Anaconda\lib\site-packages\keras\src\engine\training.py:3079: UserWarning: You
are saving your model as an HDF5 file via `model.save()`. This file format is cons
idered legacy. We recommend using instead the native Keras format, e.g. `model.sav
e('my_model.keras')`.
  saving_api.save_model(
```

```
72/80 [==========================>...] - ETA: 0s - loss: 81987.7500 - mae: 179.876
8
Epoch 2: val_loss improved from 88805.09375 to 85150.42969, saving model to regres
sor_weights-02-85150.430.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 78983.8438 - mae: 17
7.4560 - val_loss: 85150.4297 - val_mae: 181.1830
Epoch 3/350
72/80 [==========================>...] - ETA: 0s - loss: 80904.6797 - mae: 179.531
0
Epoch 3: val_loss did not improve from 85150.42969
80/80 [==============================] - 0s 6ms/step - loss: 79744.4062 - mae: 17
8.4410 - val_loss: 87148.1172 - val_mae: 180.1727
Epoch 4/350
80/80 [==============================] - ETA: 0s - loss: 79679.9922 - mae: 180.144
3
Epoch 4: val_loss did not improve from 85150.42969
80/80 [==============================] - 1s 7ms/step - loss: 79679.9922 - mae: 18
0.1443 - val_loss: 86781.7891 - val_mae: 186.2940
Epoch 5/350
80/80 [==============================] - ETA: 0s - loss: 78941.2656 - mae: 178.372
9
Epoch 5: val_loss improved from 85150.42969 to 84595.46875, saving model to regres
sor_weights-05-84595.469.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 78941.2656 - mae: 17
8.3729 - val_loss: 84595.4688 - val_mae: 185.1752
Epoch 6/350
73/80 [==========================>...] - ETA: 0s - loss: 79981.1641 - mae: 182.288
5
Epoch 6: val_loss improved from 84595.46875 to 82687.78906, saving model to regres
sor_weights-06-82687.789.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 78482.8750 - mae: 18
1.9034 - val_loss: 82687.7891 - val_mae: 175.8157
Epoch 7/350
69/80 [========================>.....] - ETA: 0s - loss: 78234.9297 - mae: 175.809
7
Epoch 7: val_loss did not improve from 82687.78906
80/80 [==============================] - 0s 6ms/step - loss: 75824.0938 - mae: 17
5.3165 - val_loss: 103552.0469 - val_mae: 213.1767
Epoch 8/350
80/80 [==============================] - ETA: 0s - loss: 74923.6250 - mae: 175.508
1
Epoch 8: val_loss did not improve from 82687.78906
80/80 [==============================] - 1s 6ms/step - loss: 74923.6250 - mae: 17
5.5081 - val_loss: 84574.2500 - val_mae: 180.5268
Epoch 9/350
69/80 [========================>.....] - ETA: 0s - loss: 72191.5859 - mae: 168.914
8
Epoch 9: val_loss improved from 82687.78906 to 77789.17188, saving model to regres
sor_weights-09-77789.172.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 71530.8047 - mae: 16
9.1565 - val_loss: 77789.1719 - val_mae: 169.7033
Epoch 10/350
72/80 [==========================>...] - ETA: 0s - loss: 70872.7031 - mae: 166.814
3
Epoch 10: val_loss improved from 77789.17188 to 77667.42969, saving model to regre
ssor_weights-10-77667.430.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 70603.4062 - mae: 16
8.6423 - val_loss: 77667.4297 - val_mae: 172.3755
Epoch 11/350
80/80 [==============================] - ETA: 0s - loss: 72958.1797 - mae: 173.219
2
Epoch 11: val_loss improved from 77667.42969 to 76288.79688, saving model to regre
ssor_weights-11-76288.797.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 72958.1797 - mae: 17
```

```
3.2192 - val_loss: 76288.7969 - val_mae: 168.5740
Epoch 12/350
78/80 [============================>.] - ETA: 0s - loss: 74612.7578 - mae: 177.035
1
Epoch 12: val_loss did not improve from 76288.79688
80/80 [==============================] - 1s 7ms/step - loss: 74355.3984 - mae: 17
6.7285 - val_loss: 83019.6562 - val_mae: 180.9560
Epoch 13/350
75/80 [===========================>..] - ETA: 0s - loss: 69868.0000 - mae: 168.954
2
Epoch 13: val_loss improved from 76288.79688 to 74600.02344, saving model to regre
ssor_weights-13-74600.023.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 70284.0078 - mae: 16
8.6737 - val_loss: 74600.0234 - val_mae: 165.9403
Epoch 14/350
71/80 [=========================>....] - ETA: 0s - loss: 68718.0234 - mae: 164.641
7
Epoch 14: val_loss improved from 74600.02344 to 72241.75000, saving model to regre
ssor_weights-14-72241.750.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 66884.6719 - mae: 16
4.3043 - val_loss: 72241.7500 - val_mae: 166.2406
Epoch 15/350
76/80 [===========================>..] - ETA: 0s - loss: 67046.7188 - mae: 163.927
7
Epoch 15: val_loss improved from 72241.75000 to 71819.93750, saving model to regre
ssor_weights-15-71819.938.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 65671.3828 - mae: 16
2.5640 - val_loss: 71819.9375 - val_mae: 161.8786
Epoch 16/350
77/80 [===========================>..] - ETA: 0s - loss: 66302.1953 - mae: 163.327
7
Epoch 16: val_loss improved from 71819.93750 to 71477.77344, saving model to regre
ssor_weights-16-71477.773.hdf5
80/80 [==============================] - 1s 9ms/step - loss: 65705.5625 - mae: 16
2.9917 - val_loss: 71477.7734 - val_mae: 165.0567
Epoch 17/350
71/80 [=========================>....] - ETA: 0s - loss: 70416.4141 - mae: 173.980
7
Epoch 17: val_loss did not improve from 71477.77344
80/80 [==============================] - 0s 6ms/step - loss: 68981.3438 - mae: 17
1.8394 - val_loss: 71626.0156 - val_mae: 170.4307
Epoch 18/350
76/80 [===========================>..] - ETA: 0s - loss: 64947.4883 - mae: 162.736
6
Epoch 18: val_loss improved from 71477.77344 to 70259.39062, saving model to regre
ssor_weights-18-70259.391.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 64039.8320 - mae: 16
2.2730 - val_loss: 70259.3906 - val_mae: 161.1354
Epoch 19/350
71/80 [=========================>....] - ETA: 0s - loss: 59675.2344 - mae: 162.782
1
Epoch 19: val_loss did not improve from 70259.39062
80/80 [==============================] - 1s 6ms/step - loss: 63995.2344 - mae: 16
2.3914 - val_loss: 73111.5391 - val_mae: 172.5299
Epoch 20/350
72/80 [==========================>...] - ETA: 0s - loss: 66236.8359 - mae: 167.636
7
Epoch 20: val_loss improved from 70259.39062 to 67537.35156, saving model to regre
ssor_weights-20-67537.352.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 65368.4375 - mae: 16
6.8807 - val_loss: 67537.3516 - val_mae: 161.0040
Epoch 21/350
72/80 [==========================>...] - ETA: 0s - loss: 63798.9766 - mae: 158.425
1
```

```
Epoch 21: val_loss did not improve from 67537.35156
80/80 [==============================] - 1s 6ms/step - loss: 61855.9609 - mae: 15
7.6233 - val_loss: 67968.9453 - val_mae: 160.5246
Epoch 22/350
78/80 [============================>.] - ETA: 0s - loss: 62659.7383 - mae: 162.983
3
Epoch 22: val_loss did not improve from 67537.35156
80/80 [==============================] - 1s 7ms/step - loss: 62144.1758 - mae: 16
2.2133 - val_loss: 69238.6719 - val_mae: 159.9018
Epoch 23/350
74/80 [==========================>...] - ETA: 0s - loss: 62424.0703 - mae: 159.247
8
Epoch 23: val_loss improved from 67537.35156 to 67009.60938, saving model to regre
ssor_weights-23-67009.609.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 61455.5273 - mae: 15
8.4510 - val_loss: 67009.6094 - val_mae: 163.6099
Epoch 24/350
79/80 [============================>.] - ETA: 0s - loss: 58783.1680 - mae: 156.121
0
Epoch 24: val_loss improved from 67009.60938 to 64633.08594, saving model to regre
ssor_weights-24-64633.086.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 59278.0078 - mae: 15
6.4514 - val_loss: 64633.0859 - val_mae: 155.2231
Epoch 25/350
72/80 [==========================>...] - ETA: 0s - loss: 57827.5156 - mae: 157.826
2
Epoch 25: val_loss improved from 64633.08594 to 64130.80469, saving model to regre
ssor_weights-25-64130.805.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 59776.3867 - mae: 15
7.9673 - val_loss: 64130.8047 - val_mae: 159.8861
Epoch 26/350
78/80 [============================>.] - ETA: 0s - loss: 59330.1523 - mae: 156.375
4
Epoch 26: val_loss did not improve from 64130.80469
80/80 [==============================] - 1s 7ms/step - loss: 58880.7891 - mae: 15
5.7728 - val_loss: 64501.2852 - val_mae: 159.7588
Epoch 27/350
70/80 [=========================>....] - ETA: 0s - loss: 51121.0508 - mae: 148.811
5
Epoch 27: val_loss did not improve from 64130.80469
80/80 [==============================] - 1s 7ms/step - loss: 57033.6484 - mae: 15
3.0820 - val_loss: 72671.1328 - val_mae: 180.3934
Epoch 28/350
79/80 [============================>.] - ETA: 0s - loss: 56427.3555 - mae: 154.007
1
Epoch 28: val_loss improved from 64130.80469 to 60796.83594, saving model to regre
ssor_weights-28-60796.836.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 56375.6523 - mae: 15
4.0440 - val_loss: 60796.8359 - val_mae: 150.3739
Epoch 29/350
80/80 [==============================] - ETA: 0s - loss: 54665.5508 - mae: 149.305
6
Epoch 29: val_loss improved from 60796.83594 to 60175.47656, saving model to regre
ssor_weights-29-60175.477.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 54665.5508 - mae: 14
9.3056 - val_loss: 60175.4766 - val_mae: 154.5913
Epoch 30/350
73/80 [==========================>...] - ETA: 0s - loss: 50355.2773 - mae: 146.361
7
Epoch 30: val_loss did not improve from 60175.47656
80/80 [==============================] - 1s 6ms/step - loss: 53212.5117 - mae: 14
8.0289 - val_loss: 60384.0117 - val_mae: 153.1849
Epoch 31/350
73/80 [==========================>...] - ETA: 0s - loss: 54466.0039 - mae: 153.039
```

```
6
Epoch 31: val_loss did not improve from 60175.47656
80/80 [==============================] - 0s 6ms/step - loss: 53425.9336 - mae: 15
1.5669 - val_loss: 63216.4961 - val_mae: 153.0728
Epoch 32/350
80/80 [==============================] - ETA: 0s - loss: 52546.9375 - mae: 145.434
9
Epoch 32: val_loss improved from 60175.47656 to 59070.60938, saving model to regre
ssor_weights-32-59070.609.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 52546.9375 - mae: 14
5.4349 - val_loss: 59070.6094 - val_mae: 149.4662
Epoch 33/350
70/80 [=========================>....] - ETA: 0s - loss: 48156.1992 - mae: 144.677
1
Epoch 33: val_loss improved from 59070.60938 to 57211.31641, saving model to regre
ssor_weights-33-57211.316.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 52556.0117 - mae: 14
6.1620 - val_loss: 57211.3164 - val_mae: 151.7694
Epoch 34/350
71/80 [=========================>....] - ETA: 0s - loss: 51732.9336 - mae: 145.481
6
Epoch 34: val_loss improved from 57211.31641 to 55916.24219, saving model to regre
ssor_weights-34-55916.242.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 50740.8047 - mae: 14
5.6187 - val_loss: 55916.2422 - val_mae: 146.0040
Epoch 35/350
74/80 [==========================>...] - ETA: 0s - loss: 45613.0000 - mae: 138.237
7
Epoch 35: val_loss improved from 55916.24219 to 55494.91016, saving model to regre
ssor_weights-35-55494.910.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 49035.7266 - mae: 13
9.0995 - val_loss: 55494.9102 - val_mae: 150.3178
Epoch 36/350
71/80 [=========================>....] - ETA: 0s - loss: 51106.6328 - mae: 145.143
5
Epoch 36: val_loss did not improve from 55494.91016
80/80 [==============================] - 1s 6ms/step - loss: 49701.8281 - mae: 14
4.4516 - val_loss: 55600.7422 - val_mae: 145.0783
Epoch 37/350
74/80 [==========================>...] - ETA: 0s - loss: 49172.1875 - mae: 142.682
9
Epoch 37: val_loss did not improve from 55494.91016
80/80 [==============================] - 0s 6ms/step - loss: 49463.7031 - mae: 14
3.6192 - val_loss: 55847.9961 - val_mae: 151.4101
Epoch 38/350
71/80 [=========================>....] - ETA: 0s - loss: 51332.1445 - mae: 147.480
7
Epoch 38: val_loss did not improve from 55494.91016
80/80 [==============================] - 0s 6ms/step - loss: 50718.6250 - mae: 14
7.3727 - val_loss: 59064.0117 - val_mae: 158.6001
Epoch 39/350
70/80 [=========================>....] - ETA: 0s - loss: 49212.4609 - mae: 145.008
5
Epoch 39: val_loss improved from 55494.91016 to 51103.87891, saving model to regre
ssor_weights-39-51103.879.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 48272.0234 - mae: 14
4.0294 - val_loss: 51103.8789 - val_mae: 140.4603
Epoch 40/350
74/80 [==========================>...] - ETA: 0s - loss: 45084.2344 - mae: 135.687
0
Epoch 40: val_loss did not improve from 51103.87891
80/80 [==============================] - 0s 6ms/step - loss: 44882.0273 - mae: 13
5.1453 - val_loss: 52868.4922 - val_mae: 152.3154
Epoch 41/350
```

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71/80 [=========================>....] - ETA: 0s - loss: 46349.6406 - mae: 135.588
6
Epoch 41: val_loss improved from 51103.87891 to 51037.70312, saving model to regre
ssor_weights-41-51037.703.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 45618.2930 - mae: 13
6.3604 - val_loss: 51037.7031 - val_mae: 140.6616
Epoch 42/350
71/80 [=========================>....] - ETA: 0s - loss: 42993.8164 - mae: 135.874
8
Epoch 42: val_loss did not improve from 51037.70312
80/80 [==============================] - 0s 6ms/step - loss: 44436.5781 - mae: 13
7.0025 - val_loss: 63806.0312 - val_mae: 170.2654
Epoch 43/350
80/80 [==============================] - ETA: 0s - loss: 44605.5000 - mae: 137.349
5
Epoch 43: val_loss improved from 51037.70312 to 49520.31641, saving model to regre
ssor_weights-43-49520.316.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 44605.5000 - mae: 13
7.3495 - val_loss: 49520.3164 - val_mae: 148.0588
Epoch 44/350
71/80 [=========================>....] - ETA: 0s - loss: 44663.8906 - mae: 135.904
2
Epoch 44: val_loss did not improve from 49520.31641
80/80 [==============================] - 0s 6ms/step - loss: 43578.8438 - mae: 13
5.0275 - val_loss: 50388.9766 - val_mae: 136.6909
Epoch 45/350
72/80 [==========================>...] - ETA: 0s - loss: 44387.5000 - mae: 137.180
1
Epoch 45: val_loss improved from 49520.31641 to 49390.03906, saving model to regre
ssor_weights-45-49390.039.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 42490.4492 - mae: 13
4.6917 - val_loss: 49390.0391 - val_mae: 139.6277
Epoch 46/350
71/80 [=========================>....] - ETA: 0s - loss: 41390.5391 - mae: 132.253
6
Epoch 46: val_loss improved from 49390.03906 to 44587.40625, saving model to regre
ssor_weights-46-44587.406.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 40769.9766 - mae: 13
1.4392 - val_loss: 44587.4062 - val_mae: 132.1325
Epoch 47/350
78/80 [============================>.] - ETA: 0s - loss: 40599.0039 - mae: 129.578
1
Epoch 47: val_loss did not improve from 44587.40625
80/80 [==============================] - 1s 8ms/step - loss: 40232.4570 - mae: 12
9.2470 - val_loss: 46573.2969 - val_mae: 134.2410
Epoch 48/350
80/80 [==============================] - ETA: 0s - loss: 40216.9844 - mae: 132.187
5
Epoch 48: val_loss did not improve from 44587.40625
80/80 [==============================] - 0s 6ms/step - loss: 40216.9844 - mae: 13
2.1875 - val_loss: 50573.8711 - val_mae: 146.5023
Epoch 49/350
72/80 [==========================>...] - ETA: 0s - loss: 38998.5898 - mae: 132.494
0
Epoch 49: val_loss did not improve from 44587.40625
80/80 [==============================] - 0s 6ms/step - loss: 40933.5508 - mae: 13
3.9998 - val_loss: 54137.5742 - val_mae: 149.8275
Epoch 50/350
72/80 [==========================>...] - ETA: 0s - loss: 39882.6211 - mae: 127.886
7
Epoch 50: val_loss did not improve from 44587.40625
80/80 [==============================] - 0s 6ms/step - loss: 39703.5977 - mae: 12
9.2709 - val_loss: 49777.6172 - val_mae: 151.7587
Epoch 51/350
```

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77/80 [===========================>..] - ETA: 0s - loss: 38528.8047 - mae: 126.476
3
Epoch 51: val_loss improved from 44587.40625 to 41769.60156, saving model to regre
ssor_weights-51-41769.602.hdf5
80/80 [==============================] - 0s 6ms/step - loss: 38491.4297 - mae: 12
6.6937 - val_loss: 41769.6016 - val_mae: 128.0128
Epoch 52/350
77/80 [===========================>..] - ETA: 0s - loss: 39566.9180 - mae: 131.434
8
Epoch 52: val_loss did not improve from 41769.60156
80/80 [==============================] - 1s 6ms/step - loss: 38737.5977 - mae: 13
0.2140 - val_loss: 42784.5820 - val_mae: 127.7155
Epoch 53/350
73/80 [==========================>...] - ETA: 0s - loss: 37940.9688 - mae: 127.574
2
Epoch 53: val_loss improved from 41769.60156 to 41097.23438, saving model to regre
ssor_weights-53-41097.234.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 37766.2422 - mae: 12
7.5187 - val_loss: 41097.2344 - val_mae: 125.1445
Epoch 54/350
80/80 [==============================] - ETA: 0s - loss: 35629.4414 - mae: 121.809
0
Epoch 54: val_loss improved from 41097.23438 to 39291.15234, saving model to regre
ssor_weights-54-39291.152.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 35629.4414 - mae: 12
1.8090 - val_loss: 39291.1523 - val_mae: 125.9417
Epoch 55/350
79/80 [============================>.] - ETA: 0s - loss: 34444.9062 - mae: 119.065
3
Epoch 55: val_loss did not improve from 39291.15234
80/80 [==============================] - 1s 7ms/step - loss: 34271.1289 - mae: 11
8.7541 - val_loss: 40653.0586 - val_mae: 125.8112
Epoch 56/350
79/80 [============================>.] - ETA: 0s - loss: 34845.2148 - mae: 121.589
6
Epoch 56: val_loss improved from 39291.15234 to 37378.65625, saving model to regre
ssor_weights-56-37378.656.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 34722.1016 - mae: 12
1.4540 - val_loss: 37378.6562 - val_mae: 123.6144
Epoch 57/350
72/80 [==========================>...] - ETA: 0s - loss: 35281.0625 - mae: 121.426
1
Epoch 57: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 34396.6602 - mae: 12
0.7084 - val_loss: 37508.1094 - val_mae: 121.7487
Epoch 58/350
73/80 [==========================>...] - ETA: 0s - loss: 32749.5215 - mae: 115.139
2
Epoch 58: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 32203.4570 - mae: 11
5.7546 - val_loss: 37457.8008 - val_mae: 120.8661
Epoch 59/350
76/80 [===========================>..] - ETA: 0s - loss: 34317.4961 - mae: 120.143
0
Epoch 59: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 33868.3633 - mae: 12
0.2159 - val_loss: 38607.3789 - val_mae: 128.3577
Epoch 60/350
68/80 [========================>.....] - ETA: 0s - loss: 29602.7559 - mae: 119.621
1
Epoch 60: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 33639.1406 - mae: 12
0.9017 - val_loss: 38004.1875 - val_mae: 123.8089
Epoch 61/350
```

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71/80 [========================>....] - ETA: 0s - loss: 32640.0195 - mae: 118.333
0
Epoch 61: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 31624.6816 - mae: 11
6.4993 - val_loss: 37844.2148 - val_mae: 127.0789
Epoch 62/350
76/80 [===========================>..] - ETA: 0s - loss: 31937.6445 - mae: 115.179
2
Epoch 62: val_loss did not improve from 37378.65625
80/80 [==============================] - 0s 6ms/step - loss: 32064.2012 - mae: 11
5.6470 - val_loss: 43584.9766 - val_mae: 140.4506
Epoch 63/350
75/80 [===========================>..] - ETA: 0s - loss: 30119.0312 - mae: 114.160
8
Epoch 63: val_loss improved from 37378.65625 to 35711.28516, saving model to regre
ssor_weights-63-35711.285.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 30465.6152 - mae: 11
4.1770 - val_loss: 35711.2852 - val_mae: 127.3563
Epoch 64/350
72/80 [=========================>...] - ETA: 0s - loss: 27000.3281 - mae: 111.438
8
Epoch 64: val_loss improved from 35711.28516 to 34465.57031, saving model to regre
ssor_weights-64-34465.570.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 29441.0801 - mae: 11
2.9539 - val_loss: 34465.5703 - val_mae: 117.4049
Epoch 65/350
71/80 [========================>....] - ETA: 0s - loss: 32996.3867 - mae: 121.805
7
Epoch 65: val_loss improved from 34465.57031 to 33742.07422, saving model to regre
ssor_weights-65-33742.074.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 31821.1426 - mae: 12
0.0586 - val_loss: 33742.0742 - val_mae: 121.1355
Epoch 66/350
71/80 [========================>....] - ETA: 0s - loss: 27977.9316 - mae: 108.669
1
Epoch 66: val_loss did not improve from 33742.07422
80/80 [==============================] - 0s 6ms/step - loss: 28225.3984 - mae: 10
9.3800 - val_loss: 40226.7578 - val_mae: 144.7208
Epoch 67/350
78/80 [============================>.] - ETA: 0s - loss: 28864.4336 - mae: 111.897
4
Epoch 67: val_loss improved from 33742.07422 to 33400.12500, saving model to regre
ssor_weights-67-33400.125.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 28671.8945 - mae: 11
1.7985 - val_loss: 33400.1250 - val_mae: 116.2635
Epoch 68/350
75/80 [===========================>..] - ETA: 0s - loss: 27664.5195 - mae: 108.979
2
Epoch 68: val_loss improved from 33400.12500 to 30546.83398, saving model to regre
ssor_weights-68-30546.834.hdf5
80/80 [==============================] - 0s 6ms/step - loss: 27376.2129 - mae: 10
8.7413 - val_loss: 30546.8340 - val_mae: 110.5134
Epoch 69/350
72/80 [=========================>...] - ETA: 0s - loss: 27274.8945 - mae: 105.815
2
Epoch 69: val_loss did not improve from 30546.83398
80/80 [==============================] - 0s 6ms/step - loss: 26869.5781 - mae: 10
6.5619 - val_loss: 30632.1914 - val_mae: 109.4804
Epoch 70/350
76/80 [===========================>..] - ETA: 0s - loss: 27508.7812 - mae: 109.958
5
Epoch 70: val_loss improved from 30546.83398 to 29602.58594, saving model to regre
ssor_weights-70-29602.586.hdf5
80/80 [==============================] - 1s 9ms/step - loss: 27235.1758 - mae: 10
```

```
9.9097 - val_loss: 29602.5859 - val_mae: 111.6204
Epoch 71/350
78/80 [============================>.] - ETA: 0s - loss: 23434.8828 - mae: 101.891
2
Epoch 71: val_loss did not improve from 29602.58594
80/80 [==============================] - 1s 6ms/step - loss: 25236.1836 - mae: 10
2.5033 - val_loss: 31669.2891 - val_mae: 117.3014
Epoch 72/350
72/80 [==========================>...] - ETA: 0s - loss: 26046.9277 - mae: 106.344
2
Epoch 72: val_loss did not improve from 29602.58594
80/80 [==============================] - 0s 6ms/step - loss: 25544.8066 - mae: 10
5.6255 - val_loss: 32045.2109 - val_mae: 113.6184
Epoch 73/350
76/80 [===========================>..] - ETA: 0s - loss: 24180.3242 - mae: 99.7532
Epoch 73: val_loss improved from 29602.58594 to 28971.80859, saving model to regre
ssor_weights-73-28971.809.hdf5
80/80 [==============================] - 1s 9ms/step - loss: 24360.5312 - mae: 10
0.1673 - val_loss: 28971.8086 - val_mae: 108.6653
Epoch 74/350
70/80 [=========================>....] - ETA: 0s - loss: 25032.4883 - mae: 102.304
8
Epoch 74: val_loss improved from 28971.80859 to 27943.34180, saving model to regre
ssor_weights-74-27943.342.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 24588.1289 - mae: 10
2.8468 - val_loss: 27943.3418 - val_mae: 106.6486
Epoch 75/350
75/80 [===========================>..] - ETA: 0s - loss: 24728.1992 - mae: 102.047
9
Epoch 75: val_loss did not improve from 27943.34180
80/80 [==============================] - 1s 6ms/step - loss: 24501.8105 - mae: 10
2.2744 - val_loss: 30692.7695 - val_mae: 112.6774
Epoch 76/350
76/80 [===========================>..] - ETA: 0s - loss: 24670.8613 - mae: 101.882
3
Epoch 76: val_loss did not improve from 27943.34180
80/80 [==============================] - 1s 8ms/step - loss: 24392.4160 - mae: 10
2.2353 - val_loss: 40353.4180 - val_mae: 142.1416
Epoch 77/350
73/80 [==========================>...] - ETA: 0s - loss: 22684.0137 - mae: 102.154
3
Epoch 77: val_loss did not improve from 27943.34180
80/80 [==============================] - 1s 6ms/step - loss: 24277.8965 - mae: 10
3.4819 - val_loss: 28057.7109 - val_mae: 113.3377
Epoch 78/350
74/80 [==========================>...] - ETA: 0s - loss: 22703.7031 - mae: 98.7930
Epoch 78: val_loss did not improve from 27943.34180
80/80 [==============================] - 0s 6ms/step - loss: 21865.9844 - mae: 97.
2604 - val_loss: 29270.0957 - val_mae: 109.9065
Epoch 79/350
71/80 [=========================>....] - ETA: 0s - loss: 24961.7344 - mae: 105.148
4
Epoch 79: val_loss did not improve from 27943.34180
80/80 [==============================] - 0s 6ms/step - loss: 24360.2676 - mae: 10
4.4379 - val_loss: 28508.7383 - val_mae: 103.6913
Epoch 80/350
71/80 [=========================>....] - ETA: 0s - loss: 22154.9043 - mae: 97.1527
Epoch 80: val_loss did not improve from 27943.34180
80/80 [==============================] - 0s 6ms/step - loss: 22067.7500 - mae: 97.
5834 - val_loss: 29065.0996 - val_mae: 116.3375
Epoch 81/350
76/80 [===========================>..] - ETA: 0s - loss: 21679.2480 - mae: 97.1513
Epoch 81: val_loss improved from 27943.34180 to 26783.65234, saving model to regre
ssor_weights-81-26783.652.hdf5
```

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80/80 [==============================] - 1s 7ms/step - loss: 21438.3125 - mae: 96.
7243 - val_loss: 26783.6523 - val_mae: 100.1353
Epoch 82/350
79/80 [============================>.] - ETA: 0s - loss: 21694.6523 - mae: 97.1942
Epoch 82: val_loss improved from 26783.65234 to 25962.27734, saving model to regre
ssor_weights-82-25962.277.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 21649.7188 - mae: 97.
1768 - val_loss: 25962.2773 - val_mae: 102.5116
Epoch 83/350
72/80 [==========================>...] - ETA: 0s - loss: 21581.5938 - mae: 97.3926
Epoch 83: val_loss did not improve from 25962.27734
80/80 [==============================] - 0s 6ms/step - loss: 20900.3867 - mae: 96.
0766 - val_loss: 25980.2793 - val_mae: 108.6397
Epoch 84/350
76/80 [===========================>..] - ETA: 0s - loss: 18209.1348 - mae: 88.9792
Epoch 84: val_loss improved from 25962.27734 to 23760.43750, saving model to regre
ssor_weights-84-23760.438.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 19500.0098 - mae: 89.
9133 - val_loss: 23760.4375 - val_mae: 100.7198
Epoch 85/350
71/80 [=========================>....] - ETA: 0s - loss: 21097.8281 - mae: 95.3740
Epoch 85: val_loss did not improve from 23760.43750
80/80 [==============================] - 1s 7ms/step - loss: 20369.9805 - mae: 94.
5012 - val_loss: 27073.0605 - val_mae: 104.5292
Epoch 86/350
75/80 [===========================>..] - ETA: 0s - loss: 19849.6699 - mae: 92.1008
Epoch 86: val_loss did not improve from 23760.43750
80/80 [==============================] - 0s 6ms/step - loss: 19334.7227 - mae: 91.
5152 - val_loss: 25395.2227 - val_mae: 100.9275
Epoch 87/350
77/80 [===========================>..] - ETA: 0s - loss: 22227.8516 - mae: 100.235
1
Epoch 87: val_loss did not improve from 23760.43750
80/80 [==============================] - 0s 6ms/step - loss: 22480.8203 - mae: 10
1.4962 - val_loss: 25159.5684 - val_mae: 106.3865
Epoch 88/350
71/80 [=========================>....] - ETA: 0s - loss: 19569.9766 - mae: 92.4099
Epoch 88: val_loss did not improve from 23760.43750
80/80 [==============================] - 0s 6ms/step - loss: 18794.4629 - mae: 90.
9835 - val_loss: 24465.6523 - val_mae: 97.1110
Epoch 89/350
76/80 [===========================>..] - ETA: 0s - loss: 18728.0703 - mae: 92.8806
Epoch 89: val_loss improved from 23760.43750 to 22440.09375, saving model to regre
ssor_weights-89-22440.094.hdf5
80/80 [==============================] - 0s 6ms/step - loss: 19673.1504 - mae: 92.
7391 - val_loss: 22440.0938 - val_mae: 99.0639
Epoch 90/350
73/80 [==========================>...] - ETA: 0s - loss: 20098.2227 - mae: 93.0514
Epoch 90: val_loss did not improve from 22440.09375
80/80 [==============================] - 0s 6ms/step - loss: 19624.4258 - mae: 92.
8096 - val_loss: 24077.7949 - val_mae: 107.4695
Epoch 91/350
72/80 [==========================>...] - ETA: 0s - loss: 17985.1328 - mae: 88.0308
Epoch 91: val_loss improved from 22440.09375 to 21445.29883, saving model to regre
ssor_weights-91-21445.299.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 17990.2422 - mae: 88.
7073 - val_loss: 21445.2988 - val_mae: 90.8661
Epoch 92/350
75/80 [===========================>..] - ETA: 0s - loss: 18041.9629 - mae: 88.1556
Epoch 92: val_loss did not improve from 21445.29883
80/80 [==============================] - 0s 6ms/step - loss: 18054.1680 - mae: 89.
2032 - val_loss: 23727.3145 - val_mae: 98.5058
Epoch 93/350
71/80 [=========================>....] - ETA: 0s - loss: 18968.4375 - mae: 92.9919
```

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Epoch 93: val_loss did not improve from 21445.29883
80/80 [==============================] - 0s 6ms/step - loss: 19160.7695 - mae: 93.
1055 - val_loss: 22581.1953 - val_mae: 102.1993
Epoch 94/350
72/80 [==========================>...] - ETA: 0s - loss: 17767.8594 - mae: 86.2780
Epoch 94: val_loss improved from 21445.29883 to 19943.82422, saving model to regre
ssor_weights-94-19943.824.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 17087.8496 - mae: 85.
2673 - val_loss: 19943.8242 - val_mae: 88.9435
Epoch 95/350
74/80 [==========================>...] - ETA: 0s - loss: 17927.3223 - mae: 88.7034
Epoch 95: val_loss did not improve from 19943.82422
80/80 [==============================] - 0s 6ms/step - loss: 17880.4922 - mae: 89.
4112 - val_loss: 22450.0117 - val_mae: 93.5237
Epoch 96/350
74/80 [==========================>...] - ETA: 0s - loss: 15673.6895 - mae: 83.5798
Epoch 96: val_loss did not improve from 19943.82422
80/80 [==============================] - 0s 6ms/step - loss: 16528.8418 - mae: 83.
9219 - val_loss: 20874.6641 - val_mae: 97.9785
Epoch 97/350
72/80 [==========================>...] - ETA: 0s - loss: 14538.2588 - mae: 81.1702
Epoch 97: val_loss improved from 19943.82422 to 18113.40625, saving model to regre
ssor_weights-97-18113.406.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 15812.5010 - mae: 83.
4228 - val_loss: 18113.4062 - val_mae: 87.0239
Epoch 98/350
75/80 [===========================>..] - ETA: 0s - loss: 15794.2256 - mae: 83.8080
Epoch 98: val_loss did not improve from 18113.40625
80/80 [==============================] - 0s 6ms/step - loss: 15571.8154 - mae: 83.
4928 - val_loss: 22035.4043 - val_mae: 90.9299
Epoch 99/350
72/80 [==========================>...] - ETA: 0s - loss: 15979.6914 - mae: 84.0497
Epoch 99: val_loss did not improve from 18113.40625
80/80 [==============================] - 0s 6ms/step - loss: 15870.6953 - mae: 84.
0451 - val_loss: 18400.8809 - val_mae: 84.9484
Epoch 100/350
74/80 [==========================>...] - ETA: 0s - loss: 15002.8828 - mae: 78.7864
Epoch 100: val_loss did not improve from 18113.40625
80/80 [==============================] - 1s 8ms/step - loss: 14825.1670 - mae: 78.
9279 - val_loss: 19257.3320 - val_mae: 93.1779
Epoch 101/350
72/80 [==========================>...] - ETA: 0s - loss: 15415.9004 - mae: 82.3683
Epoch 101: val_loss did not improve from 18113.40625
80/80 [==============================] - 0s 6ms/step - loss: 15158.4902 - mae: 81.
7898 - val_loss: 18641.0820 - val_mae: 90.5377
Epoch 102/350
80/80 [==============================] - ETA: 0s - loss: 15455.6592 - mae: 82.3160
Epoch 102: val_loss did not improve from 18113.40625
80/80 [==============================] - 1s 7ms/step - loss: 15455.6592 - mae: 82.
3160 - val_loss: 20893.6250 - val_mae: 102.4535
Epoch 103/350
72/80 [==========================>...] - ETA: 0s - loss: 14104.6836 - mae: 77.7212
Epoch 103: val_loss improved from 18113.40625 to 18046.66797, saving model to regr
essor_weights-103-18046.668.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 14052.5596 - mae: 77.
8042 - val_loss: 18046.6680 - val_mae: 88.5354
Epoch 104/350
79/80 [============================>.] - ETA: 0s - loss: 13846.3076 - mae: 77.5145
Epoch 104: val_loss did not improve from 18046.66797
80/80 [==============================] - 1s 6ms/step - loss: 13810.0479 - mae: 77.
4373 - val_loss: 18150.2246 - val_mae: 91.0318
Epoch 105/350
73/80 [==========================>...] - ETA: 0s - loss: 14333.9414 - mae: 80.1710
Epoch 105: val_loss improved from 18046.66797 to 16646.83984, saving model to regr
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essor_weights-105-16646.840.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 14077.2666 - mae: 79.
8074 - val_loss: 16646.8398 - val_mae: 83.4347
Epoch 106/350
76/80 [===========================>..] - ETA: 0s - loss: 13957.8984 - mae: 77.4109
Epoch 106: val_loss did not improve from 16646.83984
80/80 [==============================] - 1s 9ms/step - loss: 13814.4014 - mae: 77.
6235 - val_loss: 17032.8965 - val_mae: 88.2494
Epoch 107/350
78/80 [============================>.] - ETA: 0s - loss: 13237.3047 - mae: 75.4803
Epoch 107: val_loss improved from 16646.83984 to 16391.48047, saving model to regr
essor_weights-107-16391.480.hdf5
80/80 [==============================] - 1s 10ms/step - loss: 13140.6846 - mae: 7
5.3006 - val_loss: 16391.4805 - val_mae: 86.1338
Epoch 108/350
78/80 [============================>.] - ETA: 0s - loss: 12786.3779 - mae: 74.9160
Epoch 108: val_loss improved from 16391.48047 to 15513.94434, saving model to regr
essor_weights-108-15513.944.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 12758.5537 - mae: 75.
0651 - val_loss: 15513.9443 - val_mae: 77.6651
Epoch 109/350
74/80 [==========================>...] - ETA: 0s - loss: 14274.5430 - mae: 81.8467
Epoch 109: val_loss did not improve from 15513.94434
80/80 [==============================] - 1s 7ms/step - loss: 14147.4482 - mae: 81.
7555 - val_loss: 16233.7324 - val_mae: 85.2244
Epoch 110/350
71/80 [=========================>....] - ETA: 0s - loss: 12829.4736 - mae: 74.9399
Epoch 110: val_loss did not improve from 15513.94434
80/80 [==============================] - 1s 7ms/step - loss: 12877.4268 - mae: 75.
5250 - val_loss: 15647.2529 - val_mae: 80.7373
Epoch 111/350
75/80 [===========================>..] - ETA: 0s - loss: 12449.8096 - mae: 74.5034
Epoch 111: val_loss improved from 15513.94434 to 14951.35449, saving model to regr
essor_weights-111-14951.354.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 12529.3135 - mae: 74.
4971 - val_loss: 14951.3545 - val_mae: 78.4301
Epoch 112/350
75/80 [===========================>..] - ETA: 0s - loss: 12045.5078 - mae: 71.8430
Epoch 112: val_loss did not improve from 14951.35449
80/80 [==============================] - 0s 6ms/step - loss: 12000.2520 - mae: 72.
2228 - val_loss: 18106.1113 - val_mae: 90.4650
Epoch 113/350
71/80 [=========================>....] - ETA: 0s - loss: 11775.8223 - mae: 70.8654
Epoch 113: val_loss did not improve from 14951.35449
80/80 [==============================] - 0s 6ms/step - loss: 11637.1846 - mae: 71.
3537 - val_loss: 18621.3262 - val_mae: 101.4959
Epoch 114/350
74/80 [==========================>...] - ETA: 0s - loss: 13537.2041 - mae: 80.4310
Epoch 114: val_loss improved from 14951.35449 to 14774.61328, saving model to regr
essor_weights-114-14774.613.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 13375.4072 - mae: 79.
8694 - val_loss: 14774.6133 - val_mae: 79.7950
Epoch 115/350
73/80 [==========================>...] - ETA: 0s - loss: 11488.1846 - mae: 70.2953
Epoch 115: val_loss improved from 14774.61328 to 14285.47949, saving model to regr
essor_weights-115-14285.479.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 11295.2275 - mae: 70.
4310 - val_loss: 14285.4795 - val_mae: 74.8508
Epoch 116/350
72/80 [==========================>...] - ETA: 0s - loss: 11287.3711 - mae: 71.7956
Epoch 116: val_loss did not improve from 14285.47949
80/80 [==============================] - 0s 6ms/step - loss: 11902.1064 - mae: 73.
6035 - val_loss: 19612.7461 - val_mae: 98.2696
Epoch 117/350
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77/80 [===========================>..] - ETA: 0s - loss: 12690.5547 - mae: 77.5148
Epoch 117: val_loss improved from 14285.47949 to 12593.24121, saving model to regr
essor_weights-117-12593.241.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 12757.3105 - mae: 77.
1737 - val_loss: 12593.2412 - val_mae: 73.9296
Epoch 118/350
77/80 [===========================>..] - ETA: 0s - loss: 10968.2002 - mae: 69.9407
Epoch 118: val_loss did not improve from 12593.24121
80/80 [==============================] - 1s 6ms/step - loss: 10934.4248 - mae: 70.
1012 - val_loss: 13009.9082 - val_mae: 73.4415
Epoch 119/350
73/80 [==========================>...] - ETA: 0s - loss: 10374.8955 - mae: 68.9926
Epoch 119: val_loss did not improve from 12593.24121
80/80 [==============================] - 0s 6ms/step - loss: 10741.0000 - mae: 69.
6509 - val_loss: 15815.4160 - val_mae: 84.5406
Epoch 120/350
76/80 [===========================>..] - ETA: 0s - loss: 11443.3936 - mae: 72.1558
Epoch 120: val_loss did not improve from 12593.24121
80/80 [==============================] - 1s 6ms/step - loss: 11355.6426 - mae: 72.
1583 - val_loss: 13597.8740 - val_mae: 76.6830
Epoch 121/350
73/80 [==========================>...] - ETA: 0s - loss: 9934.3896 - mae: 65.2931
Epoch 121: val_loss improved from 12593.24121 to 12177.25977, saving model to regr
essor_weights-121-12177.260.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 9933.3799 - mae: 65.8
427 - val_loss: 12177.2598 - val_mae: 72.8449
Epoch 122/350
78/80 [============================>.] - ETA: 0s - loss: 9785.2715 - mae: 66.5026
Epoch 122: val_loss did not improve from 12177.25977
80/80 [==============================] - 0s 6ms/step - loss: 9822.9834 - mae: 66.7
494 - val_loss: 14964.4590 - val_mae: 80.4405
Epoch 123/350
74/80 [==========================>...] - ETA: 0s - loss: 9600.2617 - mae: 65.2422
Epoch 123: val_loss did not improve from 12177.25977
80/80 [==============================] - 0s 6ms/step - loss: 9674.3584 - mae: 65.7
259 - val_loss: 12430.2051 - val_mae: 71.7505
Epoch 124/350
77/80 [===========================>..] - ETA: 0s - loss: 9483.1436 - mae: 66.2210
Epoch 124: val_loss improved from 12177.25977 to 11764.79297, saving model to regr
essor_weights-124-11764.793.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 9639.9551 - mae: 66.4
442 - val_loss: 11764.7930 - val_mae: 73.6221
Epoch 125/350
76/80 [===========================>..] - ETA: 0s - loss: 9204.7891 - mae: 65.5553
Epoch 125: val_loss did not improve from 11764.79297
80/80 [==============================] - 0s 6ms/step - loss: 9455.8594 - mae: 65.6
869 - val_loss: 12432.2646 - val_mae: 71.4669
Epoch 126/350
72/80 [==========================>...] - ETA: 0s - loss: 10705.2031 - mae: 71.1791
Epoch 126: val_loss did not improve from 11764.79297
80/80 [==============================] - 1s 7ms/step - loss: 10375.6826 - mae: 70.
2125 - val_loss: 13268.9922 - val_mae: 71.5710
Epoch 127/350
71/80 [=========================>....] - ETA: 0s - loss: 9348.0088 - mae: 65.3578
Epoch 127: val_loss did not improve from 11764.79297
80/80 [==============================] - 0s 6ms/step - loss: 9435.2471 - mae: 66.0
371 - val_loss: 13472.0391 - val_mae: 81.5763
Epoch 128/350
72/80 [==========================>...] - ETA: 0s - loss: 9731.4023 - mae: 68.1327
Epoch 128: val_loss improved from 11764.79297 to 11357.42871, saving model to regr
essor_weights-128-11357.429.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 9708.6631 - mae: 68.3
920 - val_loss: 11357.4287 - val_mae: 72.4896
Epoch 129/350
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71/80 [========================>....] - ETA: 0s - loss: 10051.0361 - mae: 69.0240
Epoch 129: val_loss did not improve from 11357.42871
80/80 [==============================] - 0s 6ms/step - loss: 9938.8037 - mae: 69.2
894 - val_loss: 12015.7686 - val_mae: 67.0166
Epoch 130/350
69/80 [========================>.....] - ETA: 0s - loss: 9030.0283 - mae: 63.8336
Epoch 130: val_loss improved from 11357.42871 to 10430.10254, saving model to regr
essor_weights-130-10430.103.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 8916.1680 - mae: 63.4
676 - val_loss: 10430.1025 - val_mae: 62.9999
Epoch 131/350
72/80 [==========================>...] - ETA: 0s - loss: 8770.0879 - mae: 64.1165
Epoch 131: val_loss did not improve from 10430.10254
80/80 [==============================] - 1s 6ms/step - loss: 8626.0586 - mae: 63.4
932 - val_loss: 11469.9600 - val_mae: 75.6631
Epoch 132/350
76/80 [===========================>..] - ETA: 0s - loss: 8716.1846 - mae: 63.6110
Epoch 132: val_loss did not improve from 10430.10254
80/80 [==============================] - 1s 7ms/step - loss: 8641.8340 - mae: 63.6
175 - val_loss: 14715.6104 - val_mae: 83.0952
Epoch 133/350
77/80 [===========================>..] - ETA: 0s - loss: 10031.7979 - mae: 70.5395
Epoch 133: val_loss did not improve from 10430.10254
80/80 [==============================] - 1s 6ms/step - loss: 9954.0576 - mae: 70.3
388 - val_loss: 15825.4424 - val_mae: 87.4919
Epoch 134/350
70/80 [========================>....] - ETA: 0s - loss: 8729.1689 - mae: 65.3403
Epoch 134: val_loss improved from 10430.10254 to 9471.70117, saving model to regre
ssor_weights-134-9471.701.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 8957.6670 - mae: 65.1
982 - val_loss: 9471.7012 - val_mae: 66.7023
Epoch 135/350
73/80 [==========================>...] - ETA: 0s - loss: 7739.0684 - mae: 61.2297
Epoch 135: val_loss did not improve from 9471.70117
80/80 [==============================] - 0s 6ms/step - loss: 7984.4360 - mae: 61.6
010 - val_loss: 14160.2148 - val_mae: 93.1612
Epoch 136/350
73/80 [==========================>...] - ETA: 0s - loss: 8359.5811 - mae: 62.1127
Epoch 136: val_loss did not improve from 9471.70117
80/80 [==============================] - 0s 6ms/step - loss: 8443.0723 - mae: 63.1
142 - val_loss: 9494.5049 - val_mae: 62.6239
Epoch 137/350
69/80 [========================>.....] - ETA: 0s - loss: 8419.2520 - mae: 63.3608
Epoch 137: val_loss did not improve from 9471.70117
80/80 [==============================] - 1s 6ms/step - loss: 8126.2402 - mae: 62.4
721 - val_loss: 10439.9131 - val_mae: 73.1618
Epoch 138/350
70/80 [========================>....] - ETA: 0s - loss: 7189.4434 - mae: 58.8826
Epoch 138: val_loss did not improve from 9471.70117
80/80 [==============================] - 1s 7ms/step - loss: 7530.9258 - mae: 59.5
182 - val_loss: 10436.8252 - val_mae: 70.2133
Epoch 139/350
70/80 [========================>....] - ETA: 0s - loss: 8705.6953 - mae: 64.5773
Epoch 139: val_loss improved from 9471.70117 to 9040.08691, saving model to regres
sor_weights-139-9040.087.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 8304.8623 - mae: 63.3
846 - val_loss: 9040.0869 - val_mae: 60.6733
Epoch 140/350
74/80 [==========================>...] - ETA: 0s - loss: 7181.1958 - mae: 57.8934
Epoch 140: val_loss did not improve from 9040.08691
80/80 [==============================] - 0s 6ms/step - loss: 7217.7427 - mae: 58.0
148 - val_loss: 9077.2988 - val_mae: 60.1694
Epoch 141/350
78/80 [============================>.] - ETA: 0s - loss: 7187.7622 - mae: 57.3814
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Epoch 141: val_loss did not improve from 9040.08691
80/80 [==============================] - 1s 7ms/step - loss: 7122.3101 - mae: 57.1
395 - val_loss: 9419.3594 - val_mae: 60.3840
Epoch 142/350
73/80 [==========================>...] - ETA: 0s - loss: 6990.4053 - mae: 57.8412
Epoch 142: val_loss improved from 9040.08691 to 8968.68359, saving model to regres
sor_weights-142-8968.684.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 7109.7583 - mae: 57.9
478 - val_loss: 8968.6836 - val_mae: 63.6573
Epoch 143/350
78/80 [============================>.] - ETA: 0s - loss: 7286.9043 - mae: 59.3462
Epoch 143: val_loss improved from 8968.68359 to 8058.03662, saving model to regres
sor_weights-143-8058.037.hdf5
80/80 [==============================] - 1s 10ms/step - loss: 7297.2925 - mae: 59.
5085 - val_loss: 8058.0366 - val_mae: 57.6695
Epoch 144/350
77/80 [===========================>..] - ETA: 0s - loss: 7105.8311 - mae: 58.9464
Epoch 144: val_loss improved from 8058.03662 to 7935.68506, saving model to regres
sor_weights-144-7935.685.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 6977.5981 - mae: 58.4
788 - val_loss: 7935.6851 - val_mae: 57.9420
Epoch 145/350
74/80 [==========================>...] - ETA: 0s - loss: 7653.6377 - mae: 62.0214
Epoch 145: val_loss did not improve from 7935.68506
80/80 [==============================] - 0s 6ms/step - loss: 7628.0464 - mae: 62.0
384 - val_loss: 13015.5410 - val_mae: 83.9599
Epoch 146/350
73/80 [==========================>...] - ETA: 0s - loss: 6514.8232 - mae: 55.4223
Epoch 146: val_loss did not improve from 7935.68506
80/80 [==============================] - 1s 6ms/step - loss: 6615.0107 - mae: 55.7
910 - val_loss: 8962.5303 - val_mae: 61.1287
Epoch 147/350
74/80 [==========================>...] - ETA: 0s - loss: 6480.7681 - mae: 55.8207
Epoch 147: val_loss improved from 7935.68506 to 7850.60498, saving model to regres
sor_weights-147-7850.605.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 6408.4526 - mae: 55.0
045 - val_loss: 7850.6050 - val_mae: 54.1756
Epoch 148/350
79/80 [============================>.] - ETA: 0s - loss: 6231.2881 - mae: 53.9122
Epoch 148: val_loss improved from 7850.60498 to 7751.21680, saving model to regres
sor_weights-148-7751.217.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 6222.1748 - mae: 53.9
015 - val_loss: 7751.2168 - val_mae: 54.9803
Epoch 149/350
72/80 [==========================>...] - ETA: 0s - loss: 6143.3062 - mae: 54.0797
Epoch 149: val_loss improved from 7751.21680 to 7271.13574, saving model to regres
sor_weights-149-7271.136.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 6080.7017 - mae: 53.7
887 - val_loss: 7271.1357 - val_mae: 57.7265
Epoch 150/350
74/80 [==========================>...] - ETA: 0s - loss: 6403.1421 - mae: 55.9653
Epoch 150: val_loss did not improve from 7271.13574
80/80 [==============================] - 0s 6ms/step - loss: 6542.1001 - mae: 56.1
166 - val_loss: 8243.9639 - val_mae: 60.3656
Epoch 151/350
71/80 [=========================>....] - ETA: 0s - loss: 5523.1836 - mae: 51.7893
Epoch 151: val_loss did not improve from 7271.13574
80/80 [==============================] - 0s 6ms/step - loss: 5876.0308 - mae: 52.5
476 - val_loss: 7570.1113 - val_mae: 59.2664
Epoch 152/350
73/80 [==========================>...] - ETA: 0s - loss: 6276.3721 - mae: 54.2859
Epoch 152: val_loss improved from 7271.13574 to 6959.09717, saving model to regres
sor_weights-152-6959.097.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 6101.4849 - mae: 53.7
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858 - val_loss: 6959.0972 - val_mae: 52.5045
Epoch 153/350
76/80 [===========================>..] - ETA: 0s - loss: 5936.4912 - mae: 53.9181
Epoch 153: val_loss did not improve from 6959.09717
80/80 [==============================] - 0s 6ms/step - loss: 5848.7080 - mae: 53.7
084 - val_loss: 9237.9971 - val_mae: 61.6113
Epoch 154/350
79/80 [============================>.] - ETA: 0s - loss: 6937.5981 - mae: 58.9348
Epoch 154: val_loss did not improve from 6959.09717
80/80 [==============================] - 1s 7ms/step - loss: 6905.2715 - mae: 58.7
799 - val_loss: 7159.2778 - val_mae: 53.4091
Epoch 155/350
77/80 [===========================>..] - ETA: 0s - loss: 5212.2363 - mae: 49.8923
Epoch 155: val_loss did not improve from 6959.09717
80/80 [==============================] - 1s 8ms/step - loss: 5205.1616 - mae: 50.0
317 - val_loss: 7609.1367 - val_mae: 56.5391
Epoch 156/350
80/80 [==============================] - ETA: 0s - loss: 5316.8403 - mae: 49.9963
Epoch 156: val_loss did not improve from 6959.09717
80/80 [==============================] - 1s 6ms/step - loss: 5316.8403 - mae: 49.9
963 - val_loss: 7523.2573 - val_mae: 57.3337
Epoch 157/350
72/80 [==========================>...] - ETA: 0s - loss: 5125.0303 - mae: 48.0567
Epoch 157: val_loss did not improve from 6959.09717
80/80 [==============================] - 0s 6ms/step - loss: 5051.3257 - mae: 47.7
979 - val_loss: 8156.5288 - val_mae: 64.9167
Epoch 158/350
75/80 [===========================>..] - ETA: 0s - loss: 5476.1035 - mae: 50.6776
Epoch 158: val_loss did not improve from 6959.09717
80/80 [==============================] - 1s 7ms/step - loss: 5403.4297 - mae: 50.3
860 - val_loss: 8988.5469 - val_mae: 72.9170
Epoch 159/350
70/80 [=========================>....] - ETA: 0s - loss: 5165.9502 - mae: 48.7143
Epoch 159: val_loss improved from 6959.09717 to 6320.23096, saving model to regres
sor_weights-159-6320.231.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 5017.0200 - mae: 48.0
314 - val_loss: 6320.2310 - val_mae: 51.8063
Epoch 160/350
74/80 [==========================>...] - ETA: 0s - loss: 5138.1831 - mae: 50.0769
Epoch 160: val_loss did not improve from 6320.23096
80/80 [==============================] - 0s 6ms/step - loss: 5068.9873 - mae: 49.9
691 - val_loss: 6495.4795 - val_mae: 50.5248
Epoch 161/350
76/80 [===========================>..] - ETA: 0s - loss: 5552.8848 - mae: 52.6055
Epoch 161: val_loss did not improve from 6320.23096
80/80 [==============================] - 1s 7ms/step - loss: 5502.5288 - mae: 52.1
805 - val_loss: 6398.7827 - val_mae: 54.7753
Epoch 162/350
69/80 [========================>.....] - ETA: 0s - loss: 4993.9082 - mae: 48.3013
Epoch 162: val_loss did not improve from 6320.23096
80/80 [==============================] - 0s 6ms/step - loss: 4862.9595 - mae: 47.6
784 - val_loss: 6788.3003 - val_mae: 52.2975
Epoch 163/350
79/80 [============================>.] - ETA: 0s - loss: 4794.0083 - mae: 46.7644
Epoch 163: val_loss improved from 6320.23096 to 6080.71924, saving model to regres
sor_weights-163-6080.719.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 4775.0718 - mae: 46.6
714 - val_loss: 6080.7192 - val_mae: 49.4160
Epoch 164/350
79/80 [============================>.] - ETA: 0s - loss: 4563.0840 - mae: 46.2959
Epoch 164: val_loss did not improve from 6080.71924
80/80 [==============================] - 1s 6ms/step - loss: 4550.0410 - mae: 46.2
611 - val_loss: 6434.7173 - val_mae: 51.5376
Epoch 165/350
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74/80 [==========================>...] - ETA: 0s - loss: 4369.2373 - mae: 45.6274
Epoch 165: val_loss did not improve from 6080.71924
80/80 [==============================] - 1s 7ms/step - loss: 4542.1182 - mae: 46.6
905 - val_loss: 6317.1621 - val_mae: 50.7033
Epoch 166/350
75/80 [===========================>..] - ETA: 0s - loss: 4395.9673 - mae: 46.4174
Epoch 166: val_loss did not improve from 6080.71924
80/80 [==============================] - 0s 6ms/step - loss: 4425.1235 - mae: 46.2
987 - val_loss: 6410.4800 - val_mae: 48.7216
Epoch 167/350
73/80 [==========================>...] - ETA: 0s - loss: 4964.2310 - mae: 49.9722
Epoch 167: val_loss improved from 6080.71924 to 5660.19238, saving model to regres
sor_weights-167-5660.192.hdf5
80/80 [==============================] - 1s 8ms/step - loss: 4963.9404 - mae: 50.2
678 - val_loss: 5660.1924 - val_mae: 50.3449
Epoch 168/350
80/80 [==============================] - ETA: 0s - loss: 4738.7520 - mae: 48.0018
Epoch 168: val_loss improved from 5660.19238 to 5310.00488, saving model to regres
sor_weights-168-5310.005.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 4738.7520 - mae: 48.0
018 - val_loss: 5310.0049 - val_mae: 47.6777
Epoch 169/350
70/80 [=========================>....] - ETA: 0s - loss: 4944.8149 - mae: 49.3633
Epoch 169: val_loss did not improve from 5310.00488
80/80 [==============================] - 1s 6ms/step - loss: 4912.0581 - mae: 49.1
528 - val_loss: 7744.2495 - val_mae: 63.1517
Epoch 170/350
75/80 [===========================>..] - ETA: 0s - loss: 4296.3115 - mae: 45.3112
Epoch 170: val_loss improved from 5310.00488 to 5289.45410, saving model to regres
sor_weights-170-5289.454.hdf5
80/80 [==============================] - 1s 10ms/step - loss: 4291.6094 - mae: 45.
3898 - val_loss: 5289.4541 - val_mae: 48.0103
Epoch 171/350
80/80 [==============================] - ETA: 0s - loss: 4073.1028 - mae: 43.5556
Epoch 171: val_loss improved from 5289.45410 to 5207.59814, saving model to regres
sor_weights-171-5207.598.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 4073.1028 - mae: 43.5
556 - val_loss: 5207.5981 - val_mae: 46.2112
Epoch 172/350
77/80 [===========================>..] - ETA: 0s - loss: 3944.1892 - mae: 43.8913
Epoch 172: val_loss did not improve from 5207.59814
80/80 [==============================] - 1s 6ms/step - loss: 3977.1399 - mae: 43.9
718 - val_loss: 5573.1401 - val_mae: 45.2715
Epoch 173/350
70/80 [=========================>....] - ETA: 0s - loss: 3719.5532 - mae: 41.7997
Epoch 173: val_loss did not improve from 5207.59814
80/80 [==============================] - 1s 7ms/step - loss: 3788.5237 - mae: 42.2
327 - val_loss: 8723.7998 - val_mae: 67.9103
Epoch 174/350
78/80 [============================>.] - ETA: 0s - loss: 4026.0381 - mae: 44.0055
Epoch 174: val_loss improved from 5207.59814 to 4914.49463, saving model to regres
sor_weights-174-4914.495.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 4038.6387 - mae: 44.1
804 - val_loss: 4914.4946 - val_mae: 47.0734
Epoch 175/350
73/80 [==========================>...] - ETA: 0s - loss: 4239.0259 - mae: 45.3733
Epoch 175: val_loss did not improve from 4914.49463
80/80 [==============================] - 0s 6ms/step - loss: 4118.7388 - mae: 44.7
654 - val_loss: 5591.4126 - val_mae: 47.6058
Epoch 176/350
75/80 [===========================>..] - ETA: 0s - loss: 3859.3303 - mae: 43.8169
Epoch 176: val_loss did not improve from 4914.49463
80/80 [==============================] - 0s 6ms/step - loss: 3954.8145 - mae: 43.9
502 - val_loss: 5507.6353 - val_mae: 49.1970
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Epoch 177/350
75/80 [===========================>..] - ETA: 0s - loss: 3607.5591 - mae: 40.9067
Epoch 177: val_loss improved from 4914.49463 to 4661.64307, saving model to regres
sor_weights-177-4661.643.hdf5
80/80 [==============================] - 0s 6ms/step - loss: 3597.7078 - mae: 40.5
722 - val_loss: 4661.6431 - val_mae: 41.9144
Epoch 178/350
75/80 [===========================>..] - ETA: 0s - loss: 4085.1284 - mae: 44.2894
Epoch 178: val_loss did not improve from 4661.64307
80/80 [==============================] - 1s 7ms/step - loss: 4016.3757 - mae: 44.0
191 - val_loss: 5605.7954 - val_mae: 47.3167
Epoch 179/350
76/80 [===========================>..] - ETA: 0s - loss: 3993.7844 - mae: 44.9238
Epoch 179: val_loss did not improve from 4661.64307
80/80 [==============================] - 1s 7ms/step - loss: 4031.1648 - mae: 44.9
708 - val_loss: 5402.2407 - val_mae: 53.4220
Epoch 180/350
73/80 [==========================>...] - ETA: 0s - loss: 3830.6377 - mae: 43.0418
Epoch 180: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3805.2390 - mae: 42.9
853 - val_loss: 5232.9907 - val_mae: 47.7159
Epoch 181/350
74/80 [==========================>...] - ETA: 0s - loss: 3457.7893 - mae: 41.0394
Epoch 181: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3545.6514 - mae: 41.4
657 - val_loss: 5141.5864 - val_mae: 44.6625
Epoch 182/350
72/80 [==========================>...] - ETA: 0s - loss: 3549.5911 - mae: 41.5805
Epoch 182: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3595.9080 - mae: 41.7
983 - val_loss: 6810.6094 - val_mae: 49.6103
Epoch 183/350
73/80 [==========================>...] - ETA: 0s - loss: 3337.5295 - mae: 40.8392
Epoch 183: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3419.3613 - mae: 40.9
558 - val_loss: 5451.4756 - val_mae: 47.5943
Epoch 184/350
73/80 [==========================>...] - ETA: 0s - loss: 3460.3572 - mae: 40.9397
Epoch 184: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3545.9214 - mae: 41.4
330 - val_loss: 5185.5762 - val_mae: 48.9029
Epoch 185/350
71/80 [=========================>....] - ETA: 0s - loss: 3264.0635 - mae: 40.2269
Epoch 185: val_loss did not improve from 4661.64307
80/80 [==============================] - 0s 6ms/step - loss: 3495.2083 - mae: 41.4
727 - val_loss: 5392.1904 - val_mae: 50.8788
Epoch 186/350
70/80 [=========================>....] - ETA: 0s - loss: 3846.2808 - mae: 43.2888
Epoch 186: val_loss improved from 4661.64307 to 3881.43945, saving model to regres
sor_weights-186-3881.439.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 3794.1411 - mae: 43.3
923 - val_loss: 3881.4395 - val_mae: 39.1128
Epoch 187/350
80/80 [==============================] - ETA: 0s - loss: 3066.5095 - mae: 37.7640
Epoch 187: val_loss did not improve from 3881.43945
80/80 [==============================] - 1s 7ms/step - loss: 3066.5095 - mae: 37.7
640 - val_loss: 4537.8813 - val_mae: 42.5737
Epoch 188/350
71/80 [=========================>....] - ETA: 0s - loss: 2937.3118 - mae: 36.9956
Epoch 188: val_loss did not improve from 3881.43945
80/80 [==============================] - 0s 6ms/step - loss: 2908.1321 - mae: 37.0
143 - val_loss: 4271.4751 - val_mae: 39.2825
Epoch 189/350
75/80 [===========================>..] - ETA: 0s - loss: 3488.8118 - mae: 42.0220
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Epoch 189: val_loss did not improve from 3881.43945
80/80 [==============================] - 0s 6ms/step - loss: 3508.8381 - mae: 41.8
978 - val_loss: 4131.4336 - val_mae: 39.8121
Epoch 190/350
73/80 [==========================>...] - ETA: 0s - loss: 2834.2371 - mae: 37.2396
Epoch 190: val_loss improved from 3881.43945 to 3754.92578, saving model to regres
sor_weights-190-3754.926.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2919.2927 - mae: 37.3
208 - val_loss: 3754.9258 - val_mae: 39.1589
Epoch 191/350
70/80 [=========================>....] - ETA: 0s - loss: 2806.7212 - mae: 36.5709
Epoch 191: val_loss did not improve from 3754.92578
80/80 [==============================] - 0s 6ms/step - loss: 2756.4299 - mae: 35.9
369 - val_loss: 4184.3970 - val_mae: 41.0970
Epoch 192/350
73/80 [==========================>...] - ETA: 0s - loss: 2983.5571 - mae: 38.0300
Epoch 192: val_loss improved from 3754.92578 to 3688.52637, saving model to regres
sor_weights-192-3688.526.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2962.7720 - mae: 38.0
442 - val_loss: 3688.5264 - val_mae: 36.8771
Epoch 193/350
71/80 [=========================>....] - ETA: 0s - loss: 3138.6204 - mae: 38.6884
Epoch 193: val_loss did not improve from 3688.52637
80/80 [==============================] - 0s 6ms/step - loss: 3388.8494 - mae: 40.5
930 - val_loss: 5380.4185 - val_mae: 50.6281
Epoch 194/350
73/80 [==========================>...] - ETA: 0s - loss: 3819.6335 - mae: 43.5376
Epoch 194: val_loss did not improve from 3688.52637
80/80 [==============================] - 1s 7ms/step - loss: 3769.5417 - mae: 43.1
534 - val_loss: 5023.4302 - val_mae: 42.7295
Epoch 195/350
75/80 [===========================>..] - ETA: 0s - loss: 3046.8550 - mae: 37.4288
Epoch 195: val_loss improved from 3688.52637 to 3454.97070, saving model to regres
sor_weights-195-3454.971.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 2982.1729 - mae: 37.1
199 - val_loss: 3454.9707 - val_mae: 36.3142
Epoch 196/350
73/80 [==========================>...] - ETA: 0s - loss: 2462.3616 - mae: 33.3870
Epoch 196: val_loss did not improve from 3454.97070
80/80 [==============================] - 0s 6ms/step - loss: 2483.6382 - mae: 33.5
971 - val_loss: 3746.5615 - val_mae: 38.1061
Epoch 197/350
69/80 [========================>.....] - ETA: 0s - loss: 2657.5786 - mae: 36.0960
Epoch 197: val_loss did not improve from 3454.97070
80/80 [==============================] - 0s 6ms/step - loss: 2625.8337 - mae: 36.0
773 - val_loss: 4898.0889 - val_mae: 43.2683
Epoch 198/350
73/80 [==========================>...] - ETA: 0s - loss: 3855.1685 - mae: 45.4006
Epoch 198: val_loss did not improve from 3454.97070
80/80 [==============================] - 0s 6ms/step - loss: 3724.2852 - mae: 44.5
782 - val_loss: 4349.7964 - val_mae: 46.8063
Epoch 199/350
74/80 [==========================>...] - ETA: 0s - loss: 2930.8875 - mae: 37.6994
Epoch 199: val_loss did not improve from 3454.97070
80/80 [==============================] - 1s 7ms/step - loss: 3027.8015 - mae: 38.0
918 - val_loss: 4628.2505 - val_mae: 47.2891
Epoch 200/350
72/80 [==========================>...] - ETA: 0s - loss: 6346.7915 - mae: 55.8903
Epoch 200: val_loss did not improve from 3454.97070
80/80 [==============================] - 0s 6ms/step - loss: 6040.2896 - mae: 54.0
243 - val_loss: 4308.9985 - val_mae: 44.3341
Epoch 201/350
70/80 [=========================>....] - ETA: 0s - loss: 2735.2310 - mae: 36.4830
Epoch 201: val_loss did not improve from 3454.97070
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80/80 [==============================] - 0s 6ms/step - loss: 2747.0151 - mae: 36.8
902 - val_loss: 3916.2097 - val_mae: 39.7325
Epoch 202/350
74/80 [==========================>...] - ETA: 0s - loss: 3097.0774 - mae: 38.0882
Epoch 202: val_loss did not improve from 3454.97070
80/80 [==============================] - 0s 6ms/step - loss: 3055.3000 - mae: 37.8
910 - val_loss: 4301.1250 - val_mae: 44.5302
Epoch 203/350
80/80 [==============================] - ETA: 0s - loss: 2617.4729 - mae: 35.2236
Epoch 203: val_loss improved from 3454.97070 to 3111.08423, saving model to regres
sor_weights-203-3111.084.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2617.4729 - mae: 35.2
236 - val_loss: 3111.0842 - val_mae: 37.2758
Epoch 204/350
72/80 [==========================>...] - ETA: 0s - loss: 2269.7827 - mae: 32.7548
Epoch 204: val_loss improved from 3111.08423 to 2988.68555, saving model to regres
sor_weights-204-2988.686.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2270.1406 - mae: 32.9
029 - val_loss: 2988.6855 - val_mae: 34.0675
Epoch 205/350
78/80 [============================>.] - ETA: 0s - loss: 2539.7363 - mae: 34.7978
Epoch 205: val_loss did not improve from 2988.68555
80/80 [==============================] - 1s 7ms/step - loss: 2553.1089 - mae: 35.0
231 - val_loss: 3571.8066 - val_mae: 37.9526
Epoch 206/350
69/80 [========================>.....] - ETA: 0s - loss: 2300.2185 - mae: 33.3083
Epoch 206: val_loss did not improve from 2988.68555
80/80 [==============================] - 1s 6ms/step - loss: 2352.0715 - mae: 33.1
766 - val_loss: 3264.5273 - val_mae: 35.4158
Epoch 207/350
73/80 [==========================>...] - ETA: 0s - loss: 2309.2085 - mae: 32.2397
Epoch 207: val_loss did not improve from 2988.68555
80/80 [==============================] - 0s 6ms/step - loss: 2269.8157 - mae: 32.2
021 - val_loss: 3088.2354 - val_mae: 33.3363
Epoch 208/350
79/80 [============================>.] - ETA: 0s - loss: 2222.1619 - mae: 32.1442
Epoch 208: val_loss improved from 2988.68555 to 2819.05811, saving model to regres
sor_weights-208-2819.058.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2236.6575 - mae: 32.2
835 - val_loss: 2819.0581 - val_mae: 34.0478
Epoch 209/350
73/80 [==========================>...] - ETA: 0s - loss: 2391.7913 - mae: 33.4476
Epoch 209: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2347.2061 - mae: 33.3
066 - val_loss: 3028.4702 - val_mae: 36.0186
Epoch 210/350
70/80 [========================>....] - ETA: 0s - loss: 2322.4143 - mae: 33.2864
Epoch 210: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2271.4324 - mae: 33.0
474 - val_loss: 2939.5793 - val_mae: 33.7234
Epoch 211/350
74/80 [==========================>...] - ETA: 0s - loss: 2280.0654 - mae: 32.1215
Epoch 211: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2248.9507 - mae: 31.9
162 - val_loss: 3426.6318 - val_mae: 41.1121
Epoch 212/350
80/80 [==============================] - ETA: 0s - loss: 2583.8779 - mae: 36.3189
Epoch 212: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2583.8779 - mae: 36.3
189 - val_loss: 3041.5764 - val_mae: 36.7259
Epoch 213/350
71/80 [========================>....] - ETA: 0s - loss: 2116.7280 - mae: 32.0292
Epoch 213: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2215.6130 - mae: 32.7
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822 - val_loss: 3002.1975 - val_mae: 35.1730
Epoch 214/350
72/80 [=========================>...] - ETA: 0s - loss: 2606.6189 - mae: 35.2425
Epoch 214: val_loss did not improve from 2819.05811
80/80 [==============================] - 0s 6ms/step - loss: 2548.2268 - mae: 35.0
154 - val_loss: 3348.5144 - val_mae: 35.7886
Epoch 215/350
75/80 [===========================>..] - ETA: 0s - loss: 2569.4751 - mae: 34.4106
Epoch 215: val_loss improved from 2819.05811 to 2643.35181, saving model to regres
sor_weights-215-2643.352.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2555.8599 - mae: 34.4
996 - val_loss: 2643.3518 - val_mae: 32.2646
Epoch 216/350
72/80 [=========================>...] - ETA: 0s - loss: 2313.9597 - mae: 33.1044
Epoch 216: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2309.4387 - mae: 32.8
610 - val_loss: 3878.1887 - val_mae: 35.6599
Epoch 217/350
73/80 [==========================>...] - ETA: 0s - loss: 2341.3979 - mae: 33.0638
Epoch 217: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2387.5352 - mae: 33.1
237 - val_loss: 3956.2710 - val_mae: 47.1780
Epoch 218/350
74/80 [==========================>...] - ETA: 0s - loss: 2551.5349 - mae: 36.7069
Epoch 218: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2574.6284 - mae: 36.8
740 - val_loss: 3459.6086 - val_mae: 41.1598
Epoch 219/350
80/80 [==============================] - ETA: 0s - loss: 2220.6677 - mae: 32.9062
Epoch 219: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2220.6677 - mae: 32.9
062 - val_loss: 3110.4146 - val_mae: 40.4632
Epoch 220/350
74/80 [==========================>...] - ETA: 0s - loss: 1992.8234 - mae: 30.5759
Epoch 220: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2100.5364 - mae: 31.2
501 - val_loss: 3437.6040 - val_mae: 44.3097
Epoch 221/350
72/80 [==========================>...] - ETA: 0s - loss: 2100.5725 - mae: 33.2342
Epoch 221: val_loss did not improve from 2643.35181
80/80 [==============================] - 0s 6ms/step - loss: 2150.4473 - mae: 33.3
741 - val_loss: 5188.2559 - val_mae: 44.7384
Epoch 222/350
71/80 [=========================>....] - ETA: 0s - loss: 2185.2908 - mae: 31.0357
Epoch 222: val_loss improved from 2643.35181 to 2523.51562, saving model to regres
sor_weights-222-2523.516.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 2067.6445 - mae: 30.3
329 - val_loss: 2523.5156 - val_mae: 30.2176
Epoch 223/350
73/80 [==========================>...] - ETA: 0s - loss: 1767.2172 - mae: 28.2194
Epoch 223: val_loss did not improve from 2523.51562
80/80 [==============================] - 0s 6ms/step - loss: 1780.9038 - mae: 28.1
145 - val_loss: 2694.1750 - val_mae: 32.5845
Epoch 224/350
72/80 [==========================>...] - ETA: 0s - loss: 2010.1808 - mae: 31.6097
Epoch 224: val_loss did not improve from 2523.51562
80/80 [==============================] - 0s 6ms/step - loss: 1997.3987 - mae: 31.5
260 - val_loss: 3268.8093 - val_mae: 36.0295
Epoch 225/350
73/80 [==========================>...] - ETA: 0s - loss: 2453.5535 - mae: 35.5392
Epoch 225: val_loss did not improve from 2523.51562
80/80 [==============================] - 0s 6ms/step - loss: 2486.2869 - mae: 35.7
901 - val_loss: 5321.9473 - val_mae: 60.0554
Epoch 226/350
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78/80 [===========================>.] - ETA: 0s - loss: 2234.7073 - mae: 33.5040
Epoch 226: val_loss improved from 2523.51562 to 2519.00439, saving model to regres
sor_weights-226-2519.004.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2222.2363 - mae: 33.4
242 - val_loss: 2519.0044 - val_mae: 30.9378
Epoch 227/350
70/80 [=========================>....] - ETA: 0s - loss: 2397.8154 - mae: 33.3163
Epoch 227: val_loss did not improve from 2519.00439
80/80 [==============================] - 0s 6ms/step - loss: 2363.6072 - mae: 33.3
814 - val_loss: 3127.9724 - val_mae: 34.2370
Epoch 228/350
74/80 [==========================>...] - ETA: 0s - loss: 1963.9515 - mae: 30.6620
Epoch 228: val_loss did not improve from 2519.00439
80/80 [==============================] - 0s 6ms/step - loss: 1963.5632 - mae: 30.8
682 - val_loss: 3490.2454 - val_mae: 41.2958
Epoch 229/350
73/80 [==========================>...] - ETA: 0s - loss: 1853.9307 - mae: 29.4629
Epoch 229: val_loss did not improve from 2519.00439
80/80 [==============================] - 0s 6ms/step - loss: 1891.0170 - mae: 29.7
163 - val_loss: 3042.6367 - val_mae: 34.2681
Epoch 230/350
80/80 [==============================] - ETA: 0s - loss: 2574.3237 - mae: 35.0797
Epoch 230: val_loss did not improve from 2519.00439
80/80 [==============================] - 0s 6ms/step - loss: 2574.3237 - mae: 35.0
797 - val_loss: 3291.0681 - val_mae: 42.3369
Epoch 231/350
72/80 [==========================>...] - ETA: 0s - loss: 2171.4583 - mae: 32.2462
Epoch 231: val_loss improved from 2519.00439 to 2096.59448, saving model to regres
sor_weights-231-2096.594.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 2092.5979 - mae: 31.7
073 - val_loss: 2096.5945 - val_mae: 28.7356
Epoch 232/350
80/80 [==============================] - ETA: 0s - loss: 1682.0513 - mae: 28.3609
Epoch 232: val_loss did not improve from 2096.59448
80/80 [==============================] - 1s 6ms/step - loss: 1682.0513 - mae: 28.3
609 - val_loss: 2586.7227 - val_mae: 27.1825
Epoch 233/350
77/80 [===========================>..] - ETA: 0s - loss: 1863.9452 - mae: 29.3770
Epoch 233: val_loss did not improve from 2096.59448
80/80 [==============================] - 1s 6ms/step - loss: 1876.0519 - mae: 29.6
278 - val_loss: 2617.2959 - val_mae: 31.7901
Epoch 234/350
73/80 [==========================>...] - ETA: 0s - loss: 1776.7322 - mae: 29.0689
Epoch 234: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1856.6005 - mae: 29.6
023 - val_loss: 3471.5122 - val_mae: 40.6674
Epoch 235/350
78/80 [===========================>.] - ETA: 0s - loss: 1857.1122 - mae: 30.7754
Epoch 235: val_loss did not improve from 2096.59448
80/80 [==============================] - 1s 7ms/step - loss: 1874.4810 - mae: 30.7
800 - val_loss: 2808.7886 - val_mae: 34.0271
Epoch 236/350
75/80 [===========================>..] - ETA: 0s - loss: 1854.0343 - mae: 30.7301
Epoch 236: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1871.2681 - mae: 30.6
576 - val_loss: 2433.1865 - val_mae: 28.4003
Epoch 237/350
71/80 [=========================>....] - ETA: 0s - loss: 2411.9729 - mae: 34.6380
Epoch 237: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 2433.2864 - mae: 35.4
028 - val_loss: 3873.7600 - val_mae: 41.0313
Epoch 238/350
72/80 [==========================>...] - ETA: 0s - loss: 2891.8589 - mae: 39.0201
Epoch 238: val_loss did not improve from 2096.59448
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80/80 [==============================] - 0s 6ms/step - loss: 2783.4688 - mae: 37.9
113 - val_loss: 2175.0325 - val_mae: 28.4992
Epoch 239/350
73/80 [==========================>...] - ETA: 0s - loss: 2082.2078 - mae: 32.7729
Epoch 239: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 2065.3901 - mae: 32.6
415 - val_loss: 3473.6099 - val_mae: 37.0831
Epoch 240/350
71/80 [=========================>....] - ETA: 0s - loss: 1734.4657 - mae: 29.1005
Epoch 240: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1728.3073 - mae: 29.4
576 - val_loss: 3367.1953 - val_mae: 39.4846
Epoch 241/350
72/80 [==========================>...] - ETA: 0s - loss: 2583.9443 - mae: 35.0272
Epoch 241: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 2543.6829 - mae: 34.9
084 - val_loss: 4830.7471 - val_mae: 54.0176
Epoch 242/350
70/80 [=========================>....] - ETA: 0s - loss: 1699.0282 - mae: 28.4714
Epoch 242: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1739.4482 - mae: 28.9
538 - val_loss: 2274.6584 - val_mae: 27.3587
Epoch 243/350
74/80 [==========================>...] - ETA: 0s - loss: 1751.9664 - mae: 29.8271
Epoch 243: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1812.2229 - mae: 29.8
771 - val_loss: 2304.3813 - val_mae: 27.3491
Epoch 244/350
72/80 [==========================>...] - ETA: 0s - loss: 1594.7472 - mae: 28.1877
Epoch 244: val_loss did not improve from 2096.59448
80/80 [==============================] - 0s 6ms/step - loss: 1611.5071 - mae: 28.4
416 - val_loss: 3303.2375 - val_mae: 42.7044
Epoch 245/350
80/80 [==============================] - ETA: 0s - loss: 2245.6040 - mae: 32.7337
Epoch 245: val_loss improved from 2096.59448 to 2057.43872, saving model to regres
sor_weights-245-2057.439.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2245.6040 - mae: 32.7
337 - val_loss: 2057.4387 - val_mae: 25.0275
Epoch 246/350
74/80 [==========================>...] - ETA: 0s - loss: 1960.6284 - mae: 31.4692
Epoch 246: val_loss did not improve from 2057.43872
80/80 [==============================] - 0s 6ms/step - loss: 1934.6530 - mae: 31.2
518 - val_loss: 2434.1387 - val_mae: 32.8980
Epoch 247/350
74/80 [==========================>...] - ETA: 0s - loss: 1612.4344 - mae: 28.0727
Epoch 247: val_loss did not improve from 2057.43872
80/80 [==============================] - 0s 6ms/step - loss: 1580.0387 - mae: 27.7
515 - val_loss: 2580.7859 - val_mae: 36.9123
Epoch 248/350
70/80 [=========================>....] - ETA: 0s - loss: 1458.6274 - mae: 26.2528
Epoch 248: val_loss improved from 2057.43872 to 1982.47913, saving model to regres
sor_weights-248-1982.479.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 1560.9906 - mae: 27.0
322 - val_loss: 1982.4791 - val_mae: 26.5948
Epoch 249/350
77/80 [===========================>..] - ETA: 0s - loss: 1585.2716 - mae: 27.6533
Epoch 249: val_loss did not improve from 1982.47913
80/80 [==============================] - 1s 7ms/step - loss: 1569.9838 - mae: 27.5
755 - val_loss: 2073.0278 - val_mae: 24.9457
Epoch 250/350
76/80 [===========================>..] - ETA: 0s - loss: 1464.5005 - mae: 25.9687
Epoch 250: val_loss did not improve from 1982.47913
80/80 [==============================] - 1s 7ms/step - loss: 1477.7297 - mae: 26.1
064 - val_loss: 2012.5358 - val_mae: 27.3105
```

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Epoch 251/350
69/80 [========================>.....] - ETA: 0s - loss: 1399.8873 - mae: 26.0497
Epoch 251: val_loss did not improve from 1982.47913
80/80 [==============================] - 0s 6ms/step - loss: 1336.2537 - mae: 25.4
896 - val_loss: 2033.6134 - val_mae: 25.4881
Epoch 252/350
73/80 [==========================>...] - ETA: 0s - loss: 1525.9758 - mae: 26.9566
Epoch 252: val_loss did not improve from 1982.47913
80/80 [==============================] - 0s 6ms/step - loss: 1515.1317 - mae: 26.7
956 - val_loss: 2460.5398 - val_mae: 27.0928
Epoch 253/350
71/80 [=========================>....] - ETA: 0s - loss: 1596.1454 - mae: 28.4027
Epoch 253: val_loss did not improve from 1982.47913
80/80 [==============================] - 1s 7ms/step - loss: 1596.0118 - mae: 28.2
748 - val_loss: 2409.9763 - val_mae: 29.1957
Epoch 254/350
76/80 [===========================>..] - ETA: 0s - loss: 2126.0432 - mae: 32.3289
Epoch 254: val_loss did not improve from 1982.47913
80/80 [==============================] - 1s 8ms/step - loss: 2074.2600 - mae: 31.8
656 - val_loss: 2935.6621 - val_mae: 31.6654
Epoch 255/350
72/80 [==========================>...] - ETA: 0s - loss: 2243.5552 - mae: 34.5554
Epoch 255: val_loss improved from 1982.47913 to 1696.10352, saving model to regres
sor_weights-255-1696.104.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 2192.7825 - mae: 34.3
377 - val_loss: 1696.1035 - val_mae: 23.7757
Epoch 256/350
72/80 [==========================>...] - ETA: 0s - loss: 1688.5212 - mae: 29.8000
Epoch 256: val_loss did not improve from 1696.10352
80/80 [==============================] - 0s 6ms/step - loss: 1610.0558 - mae: 28.9
185 - val_loss: 2647.0178 - val_mae: 28.4290
Epoch 257/350
78/80 [============================>.] - ETA: 0s - loss: 1722.6953 - mae: 29.7279
Epoch 257: val_loss did not improve from 1696.10352
80/80 [==============================] - 1s 6ms/step - loss: 1715.1554 - mae: 29.6
266 - val_loss: 1819.6597 - val_mae: 25.1108
Epoch 258/350
74/80 [==========================>...] - ETA: 0s - loss: 2289.0872 - mae: 34.0378
Epoch 258: val_loss did not improve from 1696.10352
80/80 [==============================] - 1s 8ms/step - loss: 2249.4734 - mae: 33.8
637 - val_loss: 2359.5876 - val_mae: 31.0336
Epoch 259/350
80/80 [==============================] - ETA: 0s - loss: 1489.4875 - mae: 26.1725
Epoch 259: val_loss did not improve from 1696.10352
80/80 [==============================] - 1s 7ms/step - loss: 1489.4875 - mae: 26.1
725 - val_loss: 2400.2261 - val_mae: 32.0283
Epoch 260/350
71/80 [=========================>....] - ETA: 0s - loss: 1766.1812 - mae: 28.6202
Epoch 260: val_loss did not improve from 1696.10352
80/80 [==============================] - 0s 6ms/step - loss: 1705.3890 - mae: 27.9
779 - val_loss: 2051.7336 - val_mae: 28.1442
Epoch 261/350
80/80 [==============================] - ETA: 0s - loss: 1230.1500 - mae: 24.4636
Epoch 261: val_loss did not improve from 1696.10352
80/80 [==============================] - 1s 6ms/step - loss: 1230.1500 - mae: 24.4
636 - val_loss: 1809.3799 - val_mae: 24.9268
Epoch 262/350
69/80 [========================>.....] - ETA: 0s - loss: 1285.8417 - mae: 24.6529
Epoch 262: val_loss did not improve from 1696.10352
80/80 [==============================] - 1s 6ms/step - loss: 1283.7965 - mae: 24.8
466 - val_loss: 2209.1636 - val_mae: 28.1076
Epoch 263/350
80/80 [==============================] - ETA: 0s - loss: 1240.1487 - mae: 24.0096
Epoch 263: val_loss did not improve from 1696.10352
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80/80 [==============================] - 0s 6ms/step - loss: 1240.1487 - mae: 24.0
096 - val_loss: 3138.9470 - val_mae: 43.3370
Epoch 264/350
74/80 [==========================>...] - ETA: 0s - loss: 1948.5476 - mae: 31.9196
Epoch 264: val_loss improved from 1696.10352 to 1643.50476, saving model to regres
sor_weights-264-1643.505.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 1911.0604 - mae: 31.5
793 - val_loss: 1643.5048 - val_mae: 24.4946
Epoch 265/350
78/80 [============================>.] - ETA: 0s - loss: 1378.2761 - mae: 25.8338
Epoch 265: val_loss did not improve from 1643.50476
80/80 [==============================] - 1s 6ms/step - loss: 1372.1057 - mae: 25.8
006 - val_loss: 2183.2009 - val_mae: 31.2972
Epoch 266/350
73/80 [==========================>...] - ETA: 0s - loss: 1153.5657 - mae: 23.6323
Epoch 266: val_loss did not improve from 1643.50476
80/80 [==============================] - 0s 6ms/step - loss: 1153.0161 - mae: 23.8
959 - val_loss: 1810.5625 - val_mae: 23.3000
Epoch 267/350
79/80 [============================>.] - ETA: 0s - loss: 1363.1240 - mae: 25.9700
Epoch 267: val_loss did not improve from 1643.50476
80/80 [==============================] - 1s 6ms/step - loss: 1359.4089 - mae: 25.9
251 - val_loss: 2303.0388 - val_mae: 31.0063
Epoch 268/350
80/80 [==============================] - ETA: 0s - loss: 1275.3746 - mae: 24.5571
Epoch 268: val_loss did not improve from 1643.50476
80/80 [==============================] - 1s 6ms/step - loss: 1275.3746 - mae: 24.5
571 - val_loss: 3268.6133 - val_mae: 35.8012
Epoch 269/350
74/80 [==========================>...] - ETA: 0s - loss: 1590.0648 - mae: 27.2462
Epoch 269: val_loss did not improve from 1643.50476
80/80 [==============================] - 0s 6ms/step - loss: 1573.1858 - mae: 26.8
859 - val_loss: 2413.2800 - val_mae: 36.3211
Epoch 270/350
72/80 [==========================>...] - ETA: 0s - loss: 1439.3409 - mae: 26.6894
Epoch 270: val_loss did not improve from 1643.50476
80/80 [==============================] - 0s 6ms/step - loss: 1469.6647 - mae: 26.9
291 - val_loss: 2245.0791 - val_mae: 27.8187
Epoch 271/350
80/80 [==============================] - ETA: 0s - loss: 1689.7678 - mae: 29.0269
Epoch 271: val_loss improved from 1643.50476 to 1590.92688, saving model to regres
sor_weights-271-1590.927.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 1689.7678 - mae: 29.0
269 - val_loss: 1590.9269 - val_mae: 23.0601
Epoch 272/350
80/80 [==============================] - ETA: 0s - loss: 1513.6311 - mae: 27.5214
Epoch 272: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 6ms/step - loss: 1513.6311 - mae: 27.5
214 - val_loss: 2111.2578 - val_mae: 32.7381
Epoch 273/350
70/80 [=========================>....] - ETA: 0s - loss: 1102.7067 - mae: 22.8310
Epoch 273: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1125.4104 - mae: 23.0
491 - val_loss: 1762.0186 - val_mae: 24.9408
Epoch 274/350
79/80 [============================>.] - ETA: 0s - loss: 2321.6709 - mae: 32.1718
Epoch 274: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 6ms/step - loss: 2318.6409 - mae: 32.1
412 - val_loss: 1701.2856 - val_mae: 23.0397
Epoch 275/350
75/80 [===========================>..] - ETA: 0s - loss: 1627.8263 - mae: 26.3754
Epoch 275: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 6ms/step - loss: 1656.2963 - mae: 26.9
919 - val_loss: 2134.2285 - val_mae: 30.2530
```

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Epoch 276/350
72/80 [==========================>...] - ETA: 0s - loss: 1637.1165 - mae: 28.1138
Epoch 276: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1694.5135 - mae: 28.4
914 - val_loss: 2666.6279 - val_mae: 39.0767
Epoch 277/350
70/80 [=========================>....] - ETA: 0s - loss: 1730.8390 - mae: 28.7000
Epoch 277: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1664.3024 - mae: 28.1
902 - val_loss: 1612.4176 - val_mae: 23.6817
Epoch 278/350
72/80 [==========================>...] - ETA: 0s - loss: 1082.0426 - mae: 22.6049
Epoch 278: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1111.5897 - mae: 22.8
134 - val_loss: 2612.3879 - val_mae: 37.7537
Epoch 279/350
69/80 [========================>.....] - ETA: 0s - loss: 1282.8102 - mae: 24.3111
Epoch 279: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1230.5934 - mae: 23.9
354 - val_loss: 2498.9521 - val_mae: 35.0809
Epoch 280/350
72/80 [==========================>...] - ETA: 0s - loss: 1324.4905 - mae: 26.3626
Epoch 280: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1349.2717 - mae: 26.5
737 - val_loss: 1919.6487 - val_mae: 31.5343
Epoch 281/350
71/80 [=========================>....] - ETA: 0s - loss: 1434.7545 - mae: 27.4767
Epoch 281: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 7ms/step - loss: 1511.2975 - mae: 27.8
311 - val_loss: 1953.9058 - val_mae: 24.2535
Epoch 282/350
80/80 [==============================] - ETA: 0s - loss: 1513.0328 - mae: 26.9294
Epoch 282: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 6ms/step - loss: 1513.0328 - mae: 26.9
294 - val_loss: 2385.4363 - val_mae: 29.4430
Epoch 283/350
80/80 [==============================] - ETA: 0s - loss: 1551.1276 - mae: 27.4889
Epoch 283: val_loss did not improve from 1590.92688
80/80 [==============================] - 1s 7ms/step - loss: 1551.1276 - mae: 27.4
889 - val_loss: 1946.3052 - val_mae: 25.4209
Epoch 284/350
74/80 [==========================>...] - ETA: 0s - loss: 1592.2449 - mae: 27.4815
Epoch 284: val_loss did not improve from 1590.92688
80/80 [==============================] - 0s 6ms/step - loss: 1567.0596 - mae: 27.3
411 - val_loss: 2829.2354 - val_mae: 38.3190
Epoch 285/350
73/80 [==========================>...] - ETA: 0s - loss: 1097.1284 - mae: 22.7859
Epoch 285: val_loss improved from 1590.92688 to 1553.80261, saving model to regres
sor_weights-285-1553.803.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 1097.5435 - mae: 22.8
212 - val_loss: 1553.8026 - val_mae: 26.2393
Epoch 286/350
74/80 [==========================>...] - ETA: 0s - loss: 1133.4971 - mae: 23.9138
Epoch 286: val_loss did not improve from 1553.80261
80/80 [==============================] - 1s 7ms/step - loss: 1157.1300 - mae: 24.2
121 - val_loss: 3051.3696 - val_mae: 39.8702
Epoch 287/350
74/80 [==========================>...] - ETA: 0s - loss: 1468.3125 - mae: 26.3920
Epoch 287: val_loss did not improve from 1553.80261
80/80 [==============================] - 0s 6ms/step - loss: 1420.5562 - mae: 26.0
013 - val_loss: 1784.2847 - val_mae: 25.1036
Epoch 288/350
75/80 [===========================>..] - ETA: 0s - loss: 1241.7152 - mae: 24.2789
Epoch 288: val_loss did not improve from 1553.80261
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80/80 [==============================] - 0s 6ms/step - loss: 1241.8688 - mae: 24.2
052 - val_loss: 2087.4192 - val_mae: 28.7076
Epoch 289/350
77/80 [===========================>..] - ETA: 0s - loss: 973.1803 - mae: 21.4722
Epoch 289: val_loss did not improve from 1553.80261
80/80 [==============================] - 1s 6ms/step - loss: 969.0043 - mae: 21.47
33 - val_loss: 1564.7828 - val_mae: 23.4798
Epoch 290/350
73/80 [==========================>...] - ETA: 0s - loss: 965.2160 - mae: 21.7382
Epoch 290: val_loss did not improve from 1553.80261
80/80 [==============================] - 0s 6ms/step - loss: 964.5098 - mae: 21.69
46 - val_loss: 1925.3960 - val_mae: 29.5945
Epoch 291/350
75/80 [===========================>..] - ETA: 0s - loss: 1037.8923 - mae: 22.5350
Epoch 291: val_loss improved from 1553.80261 to 1427.13879, saving model to regres
sor_weights-291-1427.139.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 1015.0714 - mae: 22.2
908 - val_loss: 1427.1388 - val_mae: 20.9274
Epoch 292/350
75/80 [===========================>..] - ETA: 0s - loss: 1012.6205 - mae: 22.1630
Epoch 292: val_loss did not improve from 1427.13879
80/80 [==============================] - 0s 6ms/step - loss: 1004.0709 - mae: 22.0
730 - val_loss: 1593.7515 - val_mae: 21.3512
Epoch 293/350
75/80 [===========================>..] - ETA: 0s - loss: 1086.8768 - mae: 21.3361
Epoch 293: val_loss improved from 1427.13879 to 1399.32141, saving model to regres
sor_weights-293-1399.321.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 1088.0172 - mae: 21.3
034 - val_loss: 1399.3214 - val_mae: 22.2057
Epoch 294/350
69/80 [========================>.....] - ETA: 0s - loss: 950.0401 - mae: 21.0296
Epoch 294: val_loss did not improve from 1399.32141
80/80 [==============================] - 0s 6ms/step - loss: 938.1571 - mae: 20.84
05 - val_loss: 1970.9573 - val_mae: 25.6401
Epoch 295/350
79/80 [============================>.] - ETA: 0s - loss: 821.2801 - mae: 19.5387
Epoch 295: val_loss improved from 1399.32141 to 1376.69897, saving model to regres
sor_weights-295-1376.699.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 818.9378 - mae: 19.51
82 - val_loss: 1376.6990 - val_mae: 19.9245
Epoch 296/350
72/80 [==========================>...] - ETA: 0s - loss: 1165.7692 - mae: 24.1224
Epoch 296: val_loss did not improve from 1376.69897
80/80 [==============================] - 0s 6ms/step - loss: 1340.5894 - mae: 25.9
072 - val_loss: 3394.3674 - val_mae: 42.7881
Epoch 297/350
78/80 [============================>.] - ETA: 0s - loss: 1419.8026 - mae: 27.3626
Epoch 297: val_loss did not improve from 1376.69897
80/80 [==============================] - 1s 7ms/step - loss: 1425.5563 - mae: 27.3
336 - val_loss: 1832.4775 - val_mae: 29.3682
Epoch 298/350
71/80 [=========================>....] - ETA: 0s - loss: 1474.7979 - mae: 28.6502
Epoch 298: val_loss improved from 1376.69897 to 1327.80908, saving model to regres
sor_weights-298-1327.809.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 1387.1393 - mae: 27.6
419 - val_loss: 1327.8091 - val_mae: 20.8985
Epoch 299/350
75/80 [===========================>..] - ETA: 0s - loss: 761.3486 - mae: 18.9428
Epoch 299: val_loss did not improve from 1327.80908
80/80 [==============================] - 0s 6ms/step - loss: 767.7782 - mae: 18.99
05 - val_loss: 1650.2323 - val_mae: 22.7431
Epoch 300/350
73/80 [==========================>...] - ETA: 0s - loss: 1026.5590 - mae: 22.4598
Epoch 300: val_loss improved from 1327.80908 to 1288.02039, saving model to regres
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sor_weights-300-1288.020.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 1002.4257 - mae: 22.2
956 - val_loss: 1288.0204 - val_mae: 20.5095
Epoch 301/350
79/80 [============================>.] - ETA: 0s - loss: 908.3579 - mae: 20.9169
Epoch 301: val_loss did not improve from 1288.02039
80/80 [==============================] - 1s 6ms/step - loss: 907.1094 - mae: 20.90
02 - val_loss: 1597.2150 - val_mae: 21.9652
Epoch 302/350
70/80 [=========================>....] - ETA: 0s - loss: 1105.6792 - mae: 23.3598
Epoch 302: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 1132.6331 - mae: 23.6
936 - val_loss: 1945.5203 - val_mae: 31.6535
Epoch 303/350
73/80 [==========================>...] - ETA: 0s - loss: 1187.8558 - mae: 25.9159
Epoch 303: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 1217.5222 - mae: 26.3
190 - val_loss: 2238.6890 - val_mae: 33.5828
Epoch 304/350
75/80 [===========================>..] - ETA: 0s - loss: 1228.5861 - mae: 25.6089
Epoch 304: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 1250.1926 - mae: 25.8
543 - val_loss: 2138.0803 - val_mae: 29.2141
Epoch 305/350
73/80 [==========================>...] - ETA: 0s - loss: 908.3646 - mae: 21.0569
Epoch 305: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 958.8540 - mae: 21.75
86 - val_loss: 1522.5768 - val_mae: 21.5435
Epoch 306/350
74/80 [==========================>...] - ETA: 0s - loss: 825.7337 - mae: 19.8346
Epoch 306: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 854.7133 - mae: 20.09
40 - val_loss: 2459.5271 - val_mae: 35.6487
Epoch 307/350
72/80 [==========================>...] - ETA: 0s - loss: 884.2327 - mae: 20.3246
Epoch 307: val_loss did not improve from 1288.02039
80/80 [==============================] - 1s 7ms/step - loss: 896.7888 - mae: 20.50
28 - val_loss: 1410.4567 - val_mae: 20.5427
Epoch 308/350
80/80 [==============================] - ETA: 0s - loss: 796.3153 - mae: 19.2884
Epoch 308: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 796.3153 - mae: 19.28
84 - val_loss: 1473.5800 - val_mae: 20.3723
Epoch 309/350
74/80 [==========================>...] - ETA: 0s - loss: 739.5977 - mae: 18.5197
Epoch 309: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 747.1998 - mae: 18.58
64 - val_loss: 1692.6864 - val_mae: 26.7021
Epoch 310/350
73/80 [==========================>...] - ETA: 0s - loss: 1125.7828 - mae: 23.8248
Epoch 310: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 1119.5775 - mae: 23.6
657 - val_loss: 1387.7737 - val_mae: 21.9571
Epoch 311/350
72/80 [==========================>...] - ETA: 0s - loss: 1168.8368 - mae: 24.1599
Epoch 311: val_loss did not improve from 1288.02039
80/80 [==============================] - 0s 6ms/step - loss: 1118.0266 - mae: 23.7
091 - val_loss: 1932.0034 - val_mae: 30.6071
Epoch 312/350
74/80 [==========================>...] - ETA: 0s - loss: 1124.1281 - mae: 24.2441
Epoch 312: val_loss improved from 1288.02039 to 1233.58838, saving model to regres
sor_weights-312-1233.588.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 1113.6960 - mae: 23.9
500 - val_loss: 1233.5884 - val_mae: 19.3448
```

```
Epoch 313/350
70/80 [=========================>....] - ETA: 0s - loss: 763.4435 - mae: 18.7972
Epoch 313: val_loss did not improve from 1233.58838
80/80 [==============================] - 0s 6ms/step - loss: 751.6117 - mae: 18.73
28 - val_loss: 1284.9498 - val_mae: 19.6495
Epoch 314/350
71/80 [=========================>....] - ETA: 0s - loss: 784.9381 - mae: 19.4791
Epoch 314: val_loss did not improve from 1233.58838
80/80 [==============================] - 0s 6ms/step - loss: 780.6959 - mae: 19.52
99 - val_loss: 1653.0955 - val_mae: 25.4327
Epoch 315/350
71/80 [=========================>....] - ETA: 0s - loss: 1059.6907 - mae: 23.5193
Epoch 315: val_loss did not improve from 1233.58838
80/80 [==============================] - 0s 6ms/step - loss: 1010.6072 - mae: 22.8
258 - val_loss: 1378.4463 - val_mae: 19.5149
Epoch 316/350
76/80 [===========================>..] - ETA: 0s - loss: 729.6227 - mae: 18.6652
Epoch 316: val_loss did not improve from 1233.58838
80/80 [==============================] - 1s 8ms/step - loss: 757.6572 - mae: 19.11
31 - val_loss: 2152.1265 - val_mae: 28.2337
Epoch 317/350
71/80 [=========================>....] - ETA: 0s - loss: 1629.6476 - mae: 30.5410
Epoch 317: val_loss did not improve from 1233.58838
80/80 [==============================] - 0s 6ms/step - loss: 1632.4497 - mae: 30.4
214 - val_loss: 1912.8048 - val_mae: 23.2829
Epoch 318/350
80/80 [==============================] - ETA: 0s - loss: 3330.8110 - mae: 41.3611
Epoch 318: val_loss improved from 1233.58838 to 1227.09900, saving model to regres
sor_weights-318-1227.099.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 3330.8110 - mae: 41.3
611 - val_loss: 1227.0990 - val_mae: 19.0070
Epoch 319/350
74/80 [==========================>...] - ETA: 0s - loss: 1020.5293 - mae: 21.9831
Epoch 319: val_loss did not improve from 1227.09900
80/80 [==============================] - 1s 7ms/step - loss: 1052.9945 - mae: 22.4
954 - val_loss: 1429.8992 - val_mae: 22.5532
Epoch 320/350
77/80 [===========================>..] - ETA: 0s - loss: 990.2108 - mae: 22.1682
Epoch 320: val_loss did not improve from 1227.09900
80/80 [==============================] - 1s 7ms/step - loss: 995.2682 - mae: 22.23
58 - val_loss: 1368.6864 - val_mae: 21.7286
Epoch 321/350
74/80 [==========================>...] - ETA: 0s - loss: 740.6024 - mae: 18.2209
Epoch 321: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 735.0356 - mae: 18.12
58 - val_loss: 1383.7961 - val_mae: 19.5260
Epoch 322/350
78/80 [============================>.] - ETA: 0s - loss: 752.5143 - mae: 18.5352
Epoch 322: val_loss did not improve from 1227.09900
80/80 [==============================] - 1s 7ms/step - loss: 763.6416 - mae: 18.59
04 - val_loss: 1627.7123 - val_mae: 23.6866
Epoch 323/350
74/80 [==========================>...] - ETA: 0s - loss: 656.6492 - mae: 16.9209
Epoch 323: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 661.5346 - mae: 17.06
53 - val_loss: 1264.4202 - val_mae: 17.5715
Epoch 324/350
79/80 [============================>.] - ETA: 0s - loss: 730.3694 - mae: 18.1895
Epoch 324: val_loss did not improve from 1227.09900
80/80 [==============================] - 1s 7ms/step - loss: 727.4406 - mae: 18.15
27 - val_loss: 1305.3613 - val_mae: 18.4607
Epoch 325/350
72/80 [==========================>...] - ETA: 0s - loss: 651.5366 - mae: 17.1438
Epoch 325: val_loss did not improve from 1227.09900
```

```
80/80 [==============================] - 0s 6ms/step - loss: 659.9488 - mae: 17.31
83 - val_loss: 1449.8442 - val_mae: 21.4595
Epoch 326/350
72/80 [==========================>...] - ETA: 0s - loss: 689.4116 - mae: 18.1455
Epoch 326: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 723.3284 - mae: 18.60
83 - val_loss: 1529.8300 - val_mae: 24.3213
Epoch 327/350
75/80 [===========================>..] - ETA: 0s - loss: 810.6590 - mae: 20.0662
Epoch 327: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 808.9097 - mae: 20.11
69 - val_loss: 1707.6467 - val_mae: 24.4538
Epoch 328/350
72/80 [==========================>...] - ETA: 0s - loss: 689.1965 - mae: 18.4656
Epoch 328: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 695.5989 - mae: 18.49
92 - val_loss: 1257.5422 - val_mae: 21.1339
Epoch 329/350
74/80 [==========================>...] - ETA: 0s - loss: 816.5288 - mae: 20.1657
Epoch 329: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 807.1086 - mae: 20.17
73 - val_loss: 1353.7592 - val_mae: 24.3721
Epoch 330/350
74/80 [==========================>...] - ETA: 0s - loss: 1355.1426 - mae: 25.2052
Epoch 330: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 1344.0233 - mae: 25.2
674 - val_loss: 1300.7876 - val_mae: 22.9265
Epoch 331/350
74/80 [==========================>...] - ETA: 0s - loss: 1071.2916 - mae: 23.0706
Epoch 331: val_loss did not improve from 1227.09900
80/80 [==============================] - 0s 6ms/step - loss: 1061.3141 - mae: 22.8
764 - val_loss: 1762.1349 - val_mae: 20.7695
Epoch 332/350
74/80 [==========================>...] - ETA: 0s - loss: 789.0519 - mae: 19.1010
Epoch 332: val_loss improved from 1227.09900 to 1180.59814, saving model to regres
sor_weights-332-1180.598.hdf5
80/80 [==============================] - 0s 6ms/step - loss: 764.6959 - mae: 18.82
17 - val_loss: 1180.5981 - val_mae: 19.1362
Epoch 333/350
73/80 [==========================>...] - ETA: 0s - loss: 716.3111 - mae: 18.7680
Epoch 333: val_loss did not improve from 1180.59814
80/80 [==============================] - 0s 6ms/step - loss: 725.3209 - mae: 19.12
70 - val_loss: 1284.2356 - val_mae: 20.9421
Epoch 334/350
71/80 [=========================>....] - ETA: 0s - loss: 725.6735 - mae: 19.2124
Epoch 334: val_loss did not improve from 1180.59814
80/80 [==============================] - 1s 7ms/step - loss: 747.0513 - mae: 19.41
79 - val_loss: 1561.0117 - val_mae: 20.3717
Epoch 335/350
69/80 [========================>.....] - ETA: 0s - loss: 796.4521 - mae: 19.5539
Epoch 335: val_loss improved from 1180.59814 to 1168.22241, saving model to regres
sor_weights-335-1168.222.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 790.8794 - mae: 19.58
51 - val_loss: 1168.2224 - val_mae: 16.3420
Epoch 336/350
78/80 [============================>.] - ETA: 0s - loss: 953.3543 - mae: 21.9423
Epoch 336: val_loss did not improve from 1168.22241
80/80 [==============================] - 1s 6ms/step - loss: 954.6682 - mae: 21.95
70 - val_loss: 1295.0427 - val_mae: 23.1587
Epoch 337/350
78/80 [============================>.] - ETA: 0s - loss: 884.1991 - mae: 21.4638
Epoch 337: val_loss did not improve from 1168.22241
80/80 [==============================] - 1s 8ms/step - loss: 873.1633 - mae: 21.32
15 - val_loss: 1225.1069 - val_mae: 23.0618
```

```
Epoch 338/350
78/80 [============================>.] - ETA: 0s - loss: 756.2512 - mae: 19.3394
Epoch 338: val_loss did not improve from 1168.22241
80/80 [==============================] - 1s 6ms/step - loss: 768.9896 - mae: 19.47
24 - val_loss: 1460.0798 - val_mae: 20.6670
Epoch 339/350
78/80 [============================>.] - ETA: 0s - loss: 1096.5891 - mae: 25.0116
Epoch 339: val_loss did not improve from 1168.22241
80/80 [==============================] - 1s 7ms/step - loss: 1090.8258 - mae: 24.9
529 - val_loss: 1267.9713 - val_mae: 22.4405
Epoch 340/350
71/80 [=========================>....] - ETA: 0s - loss: 687.8968 - mae: 17.9093
Epoch 340: val_loss did not improve from 1168.22241
80/80 [==============================] - 1s 7ms/step - loss: 702.4241 - mae: 18.27
48 - val_loss: 1668.0361 - val_mae: 28.1297
Epoch 341/350
72/80 [==========================>...] - ETA: 0s - loss: 818.4285 - mae: 20.4968
Epoch 341: val_loss did not improve from 1168.22241
80/80 [==============================] - 0s 6ms/step - loss: 820.1248 - mae: 20.63
80 - val_loss: 1474.1300 - val_mae: 25.4259
Epoch 342/350
72/80 [==========================>...] - ETA: 0s - loss: 1333.1740 - mae: 27.2549
Epoch 342: val_loss did not improve from 1168.22241
80/80 [==============================] - 0s 6ms/step - loss: 1248.9860 - mae: 26.1
446 - val_loss: 1637.4370 - val_mae: 20.2945
Epoch 343/350
71/80 [=========================>....] - ETA: 0s - loss: 654.4122 - mae: 16.9902
Epoch 343: val_loss did not improve from 1168.22241
80/80 [==============================] - 0s 6ms/step - loss: 684.9915 - mae: 17.59
70 - val_loss: 1413.1656 - val_mae: 25.2506
Epoch 344/350
73/80 [==========================>...] - ETA: 0s - loss: 893.5897 - mae: 21.1263
Epoch 344: val_loss improved from 1168.22241 to 1109.91821, saving model to regres
sor_weights-344-1109.918.hdf5
80/80 [==============================] - 1s 6ms/step - loss: 863.8207 - mae: 20.73
12 - val_loss: 1109.9182 - val_mae: 18.9070
Epoch 345/350
73/80 [==========================>...] - ETA: 0s - loss: 629.9026 - mae: 17.4390
Epoch 345: val_loss did not improve from 1109.91821
80/80 [==============================] - 0s 6ms/step - loss: 665.3446 - mae: 18.04
88 - val_loss: 1355.1189 - val_mae: 21.1794
Epoch 346/350
73/80 [==========================>...] - ETA: 0s - loss: 640.4892 - mae: 17.1115
Epoch 346: val_loss did not improve from 1109.91821
80/80 [==============================] - 0s 6ms/step - loss: 655.5838 - mae: 17.28
86 - val_loss: 1293.9854 - val_mae: 18.7964
Epoch 347/350
72/80 [==========================>...] - ETA: 0s - loss: 749.5672 - mae: 18.8143
Epoch 347: val_loss did not improve from 1109.91821
80/80 [==============================] - 0s 6ms/step - loss: 758.2245 - mae: 18.94
80 - val_loss: 1178.9469 - val_mae: 17.4579
Epoch 348/350
80/80 [==============================] - ETA: 0s - loss: 574.8632 - mae: 15.5751
Epoch 348: val_loss improved from 1109.91821 to 1095.96777, saving model to regres
sor_weights-348-1095.968.hdf5
80/80 [==============================] - 1s 7ms/step - loss: 574.8632 - mae: 15.57
51 - val_loss: 1095.9678 - val_mae: 16.2032
Epoch 349/350
78/80 [============================>.] - ETA: 0s - loss: 910.0883 - mae: 22.3236
Epoch 349: val_loss did not improve from 1095.96777
80/80 [==============================] - 1s 7ms/step - loss: 904.2895 - mae: 22.23
81 - val_loss: 1121.0232 - val_mae: 18.2806
Epoch 350/350
72/80 [==========================>...] - ETA: 0s - loss: 1041.4366 - mae: 22.3303
```

```
Epoch 350: val_loss did not improve from 1095.96777
80/80 [==============================] - 0s 6ms/step - loss: 1040.6791 - mae: 22.3
723 - val_loss: 1719.6119 - val_mae: 26.8785
```

Построение графика потери

Если функция потерь на тренировочной выборке продолжает уменьшаться, в то время как на валидационной выборке начинает возрастать, это является признаком переобучения

In [31]:
```
loss_function = regressor_history.history['loss']
val_loss_function = regressor_history.history['val_loss']
epochs = range(1, len(loss_function)+1)

plt.title('Loss function (Train & Val Sets)')
plt.plot(epochs, loss_function, label='Train Loss')
plt.plot(epochs, val_loss_function, color='orange', label='Val Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss function')
plt.legend()
plt.show()
```

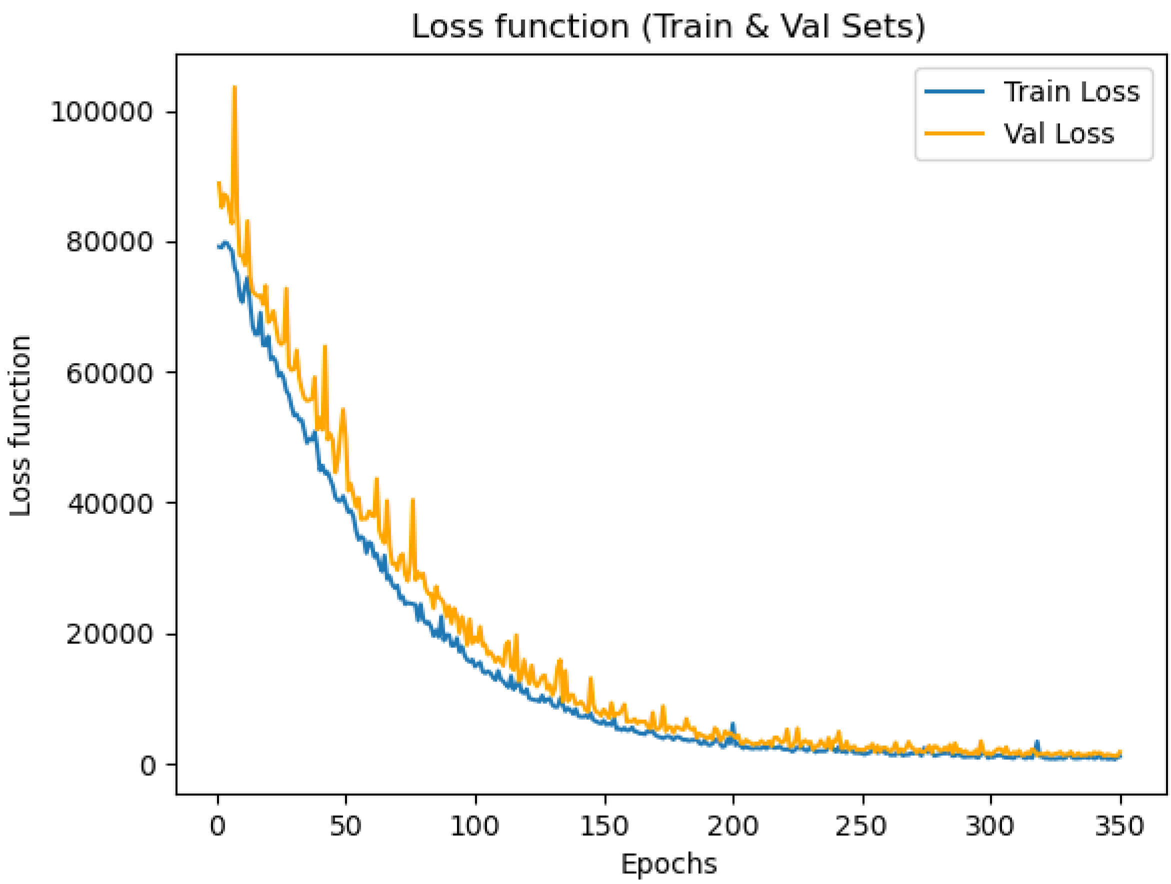
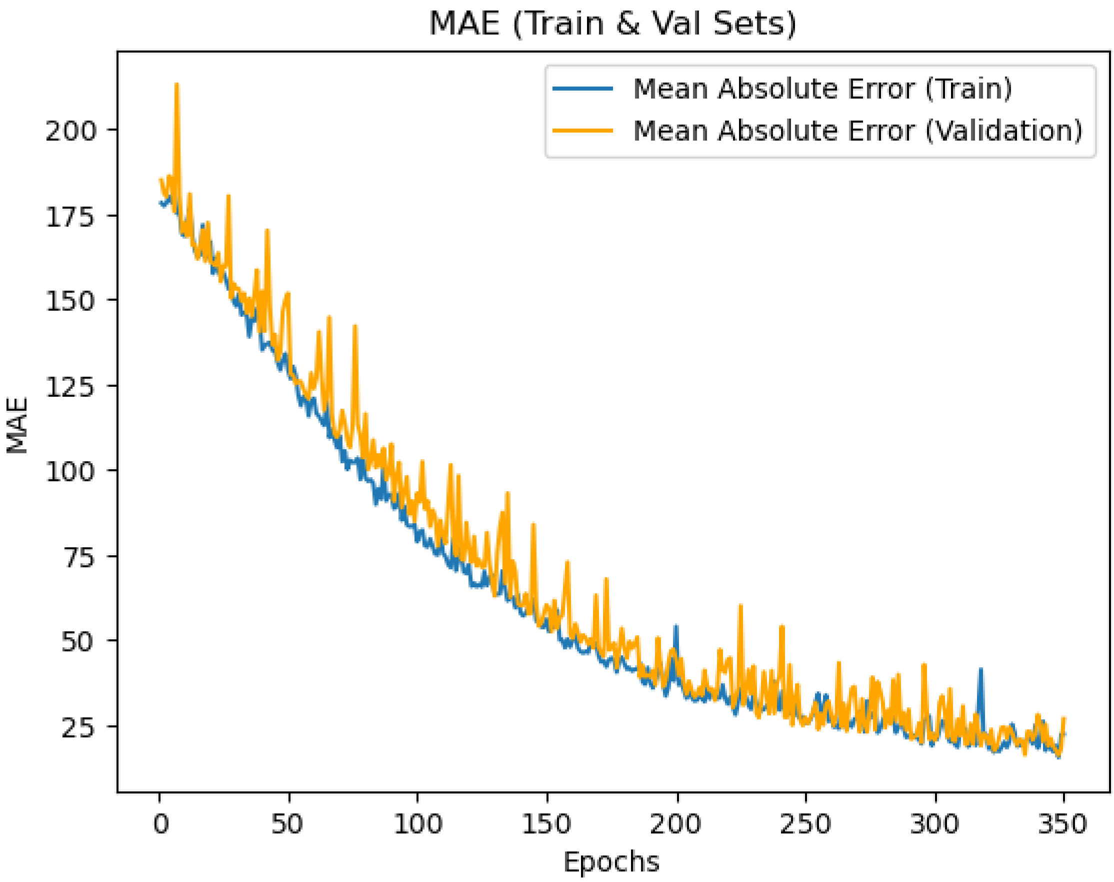


График изменения величины средней абсолютной ошибки (Mean Absolute Error, MAE) модели в процессе

Две кривые: одна для обучающего набора данных ("Mean Absolute Error (Train)") и для валидационного набора данных ("Mean Absolute Error (Validation)"). Если на графике видно, что ошибка на обучающей выборке продолжает уменьшаться, в то время как ошибка на валидационной выборке начинает увеличиваться, это может свидетельствовать о переобучении модели, когда она хорошо обучается на тренировочных данных, но плохо справляется с новыми, наблюдаемыми во время валидации данными.

In [32]:
```
mae = regressor_history.history['mae']
val_mae = regressor_history.history['val_mae']
epochs = range(1, len(mae)+1)

plt.title('MAE (Train & Val Sets)')
plt.plot(epochs, mae, label='Mean Absolute Error (Train)')
plt.plot(epochs, val_mae, color='orange', label='Mean Absolute Error (Validation)')
plt.xlabel('Epochs')
plt.ylabel('MAE')
plt.legend()
plt.show()
```



In [33]:
```
results = regressor.evaluate(X_test, y_test)
```

```
32/32 [==============================] - 0s 4ms/step - loss: 1588.5815 - mae: 28.0
636
```

In [34]:
```
y_test
```

Out[34]:
```
6901      3540
4670      7372
6134     10914
2480     10781
8744      4837
         ...
5834       688
10531    15046
1912     12806
6279      2744
3881     10903
Name: TOTALBTUCOL, Length: 995, dtype: int64
```

In [35]:
```
x_test_pattern = X_test[2, :]
y_pred = regressor.predict(x_test_pattern.reshape(1, -1))
print(y_pred[0])
```

```
1/1 [==============================] - 0s 48ms/step
[10929.391]
```

In [36]:
```
original_features = min_max_scaler.inverse_transform(x_test_pattern.reshape(1, -1))
original_features
```

Out[36]:
```
array([[3.00000000e+00, 7.00000000e+00, 2.10000000e+01, 4.61011000e+02,
        4.61000000e+02, 3.19867000e+03, 1.09138550e+04, 3.02000000e+02,
        7.16000000e+03, 0.00000000e+00, 8.10162822e+03, 1.53600000e+03,
        1.00000000e+00, 1.00000000e+00, 2.25600000e+03, 9.28817000e+02,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 7.00000000e+01,
        1.53600000e+03, 0.00000000e+00, 1.00000000e+00, 1.00000000e+00,
        0.00000000e+00, 1.00000000e+00, 9.29000000e+02, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 2.09852000e+03,
        7.16014700e+03, 0.00000000e+00, 0.00000000e+00, 4.00000000e+02,
        2.25600000e+03, 1.00000000e+00, 3.02451000e+02, 1.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        4.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        4.00000000e+02, 1.93600000e+03, 1.53600000e+03, 0.00000000e+00,
        0.00000000e+00, 1.00000000e+00, 0.00000000e+00, 5.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 2.00000000e+00,
        0.00000000e+00, 5.34080000e+04, 1.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 3.62294000e+02, 2.51373900e+03,
        8.57687100e+03, 6.00000000e+00, 1.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 2.19890000e+04, 0.00000000e+00, 0.00000000e+00,
        2.00000000e+00, 0.00000000e+00, 3.00000000e+00, 1.00000000e+01,
        0.00000000e+00, 0.00000000e+00, 1.00000000e+00, 0.00000000e+00,
        5.00000000e+00, 0.00000000e+00, 0.00000000e+00, 2.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 6.44448900e+03,
        0.00000000e+00, 3.62000000e+02, 0.00000000e+00, 0.00000000e+00,
        1.98200000e+03, 2.19885820e+04, 1.56530000e+04, 5.34080000e+04,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 6.50000000e+01, 1.00000000e+00, 8.57700000e+03,
        5.00000000e+00, 2.01427000e+02, 2.01000000e+02, 6.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 5.00000000e+00, 1.39758200e+03]])
```

In [37]:
```
x_test_pattern
```

Out[37]:
```
array([0.5       , 0.66666667, 0.76923077, 0.05960983, 0.05964549,
       0.0523986 , 0.05239854, 0.03259931, 0.017862  , 0.        ,
       0.17477496, 0.10244189, 0.        , 0.1       , 0.11532785,
       0.09676711, 0.        , 0.        , 0.        , 0.66666667,
       0.1055247 , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.06945639, 0.        , 0.        , 0.        ,
       0.        , 0.15159057, 0.1515907 , 0.        , 0.        ,
       0.05270787, 0.0682907 , 0.        , 0.22387924, 1.        ,
       0.        , 0.        , 0.        , 0.        , 0.42857143,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.0514668 , 0.09331459, 0.07118102,
       0.        , 0.        , 0.        , 0.        , 0.2       ,
       0.        , 0.        , 0.        , 0.13333333, 0.        ,
       0.04603602, 0.        , 0.        , 0.        , 0.        ,
       0.20628734, 0.2004597 , 0.20045939, 0.19047619, 1.        ,
       0.        , 0.        , 0.05070514, 0.        , 0.        ,
       0.25      , 0.        , 0.05263158, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.2       , 0.        ,
       0.        , 0.14285714, 0.        , 0.        , 0.        ,
       0.09784827, 0.        , 0.11990725, 0.        , 0.        ,
       0.69662921, 0.0978495 , 0.10359226, 0.10359278, 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.55555556,
       0.025     , 0.03018689, 0.57142857, 0.08089288, 0.08072289,
       0.22727273, 0.        , 0.        , 1.        , 0.1262606 ])
```

In [38]:
```python
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
y_pred = regressor.predict(X_test)
mse = mean_squared_error(y_test, y_pred)
mae = mean_absolute_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)
```

```
32/32 [==============================] - 0s 3ms/step
```

Метрики работы MSE, MAE, R2

In [39]:
```python
print(f"MSE: {mse}")
print(f"MAE: {mae}")
print(f"R2: {r2}")
```

```
MSE: 1588.583464797732
MAE: 28.06361318617011
R2: 0.9999828651563029
```

In [ ]: