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Федеральное государственное бюджетное образовательное учреждение
высшего образования
«Московский государственный технический университет имени Н.Э. Баумана
(национальный исследовательский университет)»
(МГТУ им. Н.Э. Баумана)

Факультет «Информатика и системы управления»

Кафедра «Системы обработки информации и управления»

Отчет по дополнительной лабораторной работе №1

«Анализ и прогнозирование временного ряда»

по дисциплине «Технологии машинного обучения»

Выполнил:
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Стукалов И.Д.
10.05.2024

Проверил:
Гапанюк Ю.Е.

2024 г.

Задание.

Выберите набор данных (датасет) для решения задачи прогнозирования временного ряда.

Визуализируйте временной ряд и его основные характеристики.

Разделите временной ряд на обучающую и тестовую выборку.

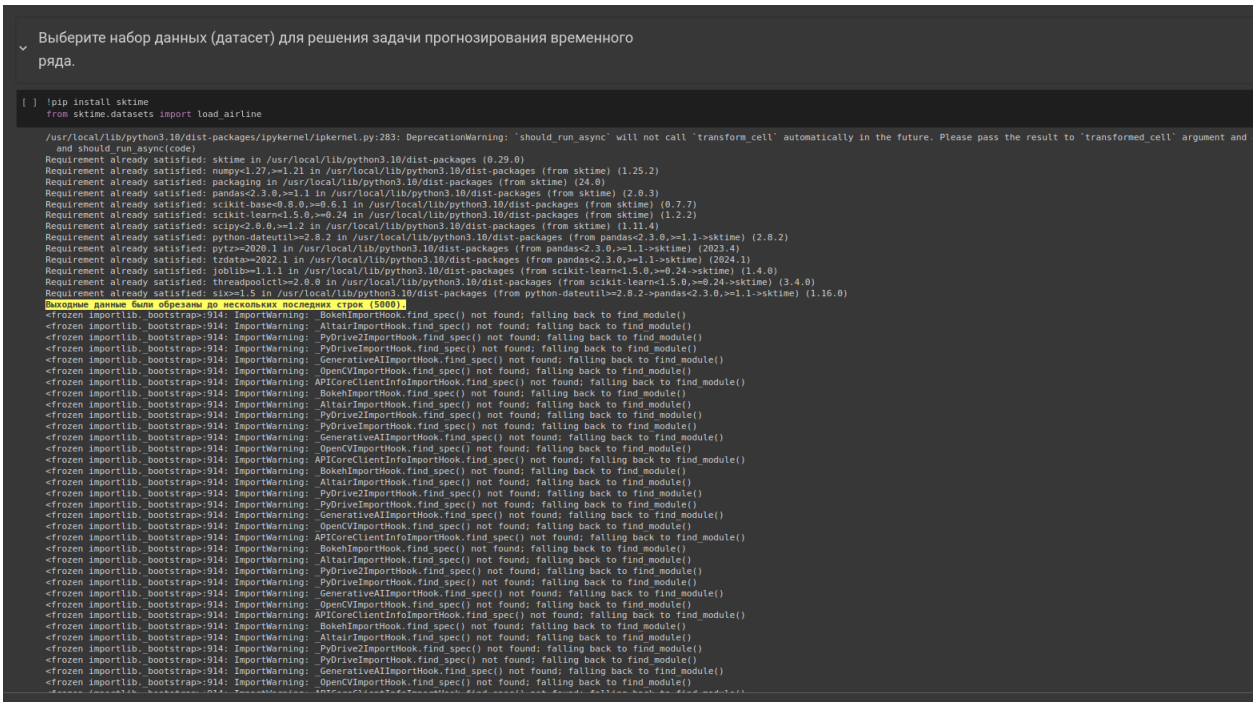
Произведите прогнозирование временного ряда с использованием следующих методов:

- один из авторегрессионных методов (ARMA, ARIMA, ...);
- метод символьной регресии;
- двумя методами на выбор из семейства МГУА (один из линейных методов COMBI / MULTI + один из нелинейных методов MIA / RIA) с использованием библиотеки gmdh.

Визуализируйте тестовую выборку и каждый из прогнозов.

Оцените качество прогноза в каждом случае с помощью подходящей метрики.

Текст программы



```
# Загрузка набора данных
al = load_airline()
al.info()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
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<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
<class 'pandas.core.series.Series'>
PeriodIndex: 144 entries, 1949-01 to 1960-12
Freq: M
Series name: Number of airline passengers
Non-Null Count  Dtype
--------------  -----
144 non-null    float64
dtypes: float64(1)
memory usage: 2.2 KB
```

Визуализируйте временной ряд и его основные характеристики.

```
import numpy as np
import pandas as pd
from matplotlib import pyplot
import matplotlib.pyplot as plt

fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Временной ряд в виде графика')
al.plot(ax=ax, legend=False)
pyplot.show()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
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<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
```

```
<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
```

```
al.head()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
Period
1949-01    112.0
1949-02    118.0
1949-03    132.0
1949-04    129.0
1949-05    121.0
Freq: M, Name: Number of airline passengers, dtype: float64
```

```
# Размер временного ряда
al.shape[0]
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
144
```

Разделите временной ряд на обучающую и тестовую выборку.

```
from sklearn.metrics import mean_squared_error
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.holtwinters import ExponentialSmoothing

# Целочисленная метка шкалы времени
xnum = list(range(al.shape[0]))
# Разделение выборки на обучающую и тестовую
Y = al.values
train_size = int(len(Y) * 0.7)
xnum_train, xnum_test = xnum[0:train_size], xnum[train_size:]
train, test = Y[0:train_size], Y[train_size:]
history_arima = [x for x in train]
history_es = [x for x in train]
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
```

Произведите прогнозирование временного ряда с использованием как минимум двух методов.

ARIMA

```
# Параметры модели (p,d,q)
arima_order = (6,1,0)
# Формирование предсказаний
predictions_arima = list()
for t in range(len(test)):
    model_arima = ARIMA(history_arima, order=arima_order)
    model_arima_fit = model_arima.fit()
    yhat_arima = model_arima_fit.forecast()[0]
    predictions_arima.append(yhat_arima)
    history_arima.append(test[t])
# Вычисление метрики RMSE
error_arima = mean_squared_error(test, predictions_arima, squared=False)
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```

```
# Формирование предсказаний
predictions_es = list()
for t in range(len(test)):
    model_es = ExponentialSmoothing(history_es)
    model_es_fit = model_es.fit()
    yhat_es = model_es_fit.forecast()[0]
    predictions_es.append(yhat_es)
    history_es.append(test[t])
# Вычисление метрики RMSE
error_es = mean_squared_error(test, predictions_es, squared=False)
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```

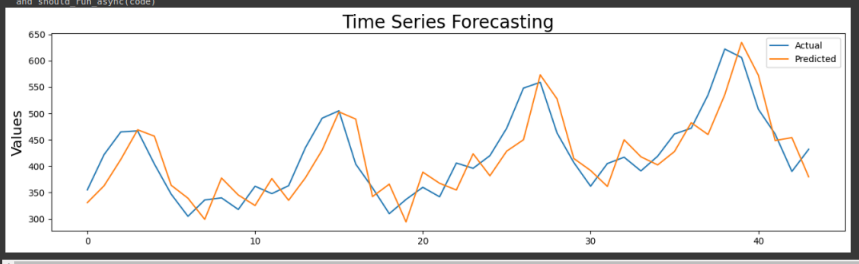
```
# Ошибка прогноза
np.mean(Y), error_arima, error_es
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
(280.2986111111111, 45.28242008258071, 49.447088816444094)
```

```
import matplotlib.pyplot as plt
plt.figure(figsize=(16,4))
plt.plot(test, label="Actual")
plt.plot(predictions_arima, label="Predicted")
plt.title('Time Series Forecasting', fontsize=20)
```

```
import matplotlib.pyplot as plt
plt.figure(figsize=(16,4))
plt.plot(test, label="Actual")
plt.plot(predictions_arima, label="Predicted")
plt.title('Time Series Forecasting', fontsize=20)
plt.ylabel('Values', fontsize=16)
plt.legend()
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```



Символьная регрессия

```
!pip install gplearn
from gplearn.genetic import SymbolicRegressor
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
Requirement already satisfied: gplearn in /usr/local/lib/python3.10/dist-packages (0.4.2)
Requirement already satisfied: scikit-learn>=1.0.2 in /usr/local/lib/python3.10/dist-packages (from gplearn) (1.2.2)
Requirement already satisfied: joblib>=1.0.0 in /usr/local/lib/python3.10/dist-packages (from gplearn) (1.4.0)
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=1.0.2->gplearn) (1.25.2)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=1.0.2->gplearn) (1.11.4)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=1.0.2->gplearn) (3.4.0)
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
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<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
```

```
[ ] function_set = ['add', 'sub', 'mul', 'div', 'sin']
    est_gp = SymbolicRegressor(population_size=500, metric='mse',
                               generations=70, stopping_criteria=0.01,
                               init_depth=(4, 10), verbose=1, function_set=function_set,
                               const_range=(-100, 100), random_state=0)
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```

```
[ ] est_gp.fit(np.array(xnum_train).reshape(-1, 1), train.reshape(-1, 1))
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
/usr/local/lib/python3.10/dist-packages/sklearn/utils/validation.py:1143: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples, ), for example using rav
  y = column_or_1d(y, warn=True)
    |   Population Average    |             Best Individual              |
---- ------------------------- ------------------------------------------ ----------
 Gen   Length          Fitness   Length          Fitness      OOB Fitness  Time Left
   0   263.65      8.79076e+46       59          4935.14              N/A      4.49m
   1   141.18      4.16457e+14       72          4638.92              N/A      1.17m
   2    73.58      2.25505e+09       78          4579.99              N/A     36.57s
   3    64.76      1.21852e+15       71          3864.76              N/A     52.18s
   4    69.55      1.25496e+11       85          3715.16              N/A      1.21m
   5    68.89      4.26607e+10       81           3012.4              N/A      1.12m
   6    78.37      1.49839e+11       81           3012.4              N/A      1.06m
   7    79.09      8.20465e+13       92          3009.99              N/A      1.16m
   8    92.35      5.15147e+10      129             2754              N/A      1.30m
   9    97.63      7.93413e+09      160          2702.81              N/A      1.30m
  10   116.83      3.03425e+11      128          1507.72              N/A      1.50m
  11   141.08      2.65532e+10      120          1507.69              N/A      3.38m
  12   146.34      4.87157e+10      112          1251.72              N/A      4.09m
  13   130.19       3.9615e+09       92          1251.68              N/A      2.27m
  14   124.99      6.31431e+09       94          1123.53              N/A      1.31m
  15   112.53      1.96229e+12       76          1101.53              N/A      1.14m
  16   106.53      9.16678e+14       93          1098.81              N/A      1.15m
  17    95.16      3.36262e+10      122          1091.08              N/A      1.32m
  18    92.79      3.91346e+10      145          1090.23              N/A      2.41m
  19   108.63      5.17989e+10      173          1089.28              N/A      1.67m
  20   129.91      9.54207e+13      151          1070.74              N/A      1.25m
  21   148.75      2.99262e+10      147          1065.74              N/A      2.00m
  22   157.96       1.114e+10       157          1021.75              N/A      1.02m
  23   150.08      1.77331e+10      267          1017.98              N/A     34.72s
  24   162.49      2.36047e+10      129          1007.37              N/A     36.25s
  25   183.90      4.04029e+10      171           977.83              N/A     37.23s
  26   204.07      3.19638e+10      171          977.829              N/A     37.54s
  27   234.97      1.37835e+10      151          966.887              N/A      1.07m
  28   188.93      5.05123e+12      175          966.461              N/A     56.66s
  29   192.81      7.17435e+09      177          965.649              N/A     39.19s
  30   193.40      7.64131e+12      327           937.59              N/A     34.12s
  31   194.48      4.10029e+09      309          905.978              N/A     32.65s
  32   240.94       3.8342e+13      335          905.978              N/A     37.54s
  33   307.25      2.16532e+10      175          879.024              N/A     41.64s
  34   283.38      1.07338e+10      175          879.024              N/A     37.21s
  35   246.97      3.58219e+10      181          876.484              N/A     33.98s
  36   206.65      3.26892e+10      163           870.93              N/A     29.56s
  37   188.83       3.7412e+10      163           870.93              N/A     26.90s
  38   183.49      4.22489e+13      171          870.757              N/A     26.06s
  39   184.69      5.11402e+10      161          869.956              N/A     33.41s
```

```
[ ] <frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
    <frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
    <frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
    <frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
```

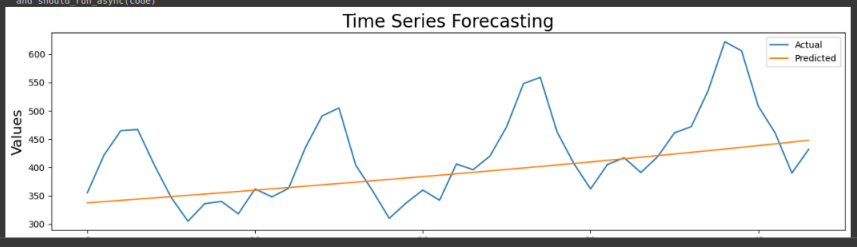
```
div(add(add(mul(sub(26.428, 26.637), mul(-91.195, 51.329)), div(mul(-70.060, sub(div(X0, 20.271), div(mul(div(mul(div(X0, -92.726), add(X0, add(X0, div(-64.562, -73.213)))), sub(X0, X0)), add(div(mul(mul(sub(26.428, 26.637),
```

```
[ ] # Предсказания
    y_gp = est_gp.predict(np.array(xnum_test).reshape(-1, 1))
    y_gp
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
array([337.4146303 , 339.60335004, 341.80088045, 344.00917373,
       346.2293616 , 348.4621579 , 350.70806389, 352.96747737,
       355.24075237, 357.5202324 , 359.83026919, 362.14723322,
       364.47951942, 366.82755023, 369.19177705, 371.57268081,
       373.97077202, 376.38659062, 378.82070573, 381.27371534,
       383.74624615, 386.23895342, 388.75252092, 391.28766102,
       393.84511483, 396.42565251, 399.03007368, 401.65920788,
       404.31391519, 406.99508693, 409.70364651, 412.44065026,
       415.20678851, 418.00338669, 420.83140651, 423.69194734,
       426.58614759, 429.51518626, 432.48028462, 435.48270796,
       438.52376748, 441.60482236, 444.72728185, 447.89260766])
```

```
plt.figure(figsize=(16,4))
plt.plot(test, label="Actual")
plt.plot(y_gp, label="Predicted")
plt.title('Time Series Forecasting', fontsize=20)
plt.ylabel('Values', fontsize=16)
plt.legend()
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```



МГУА

```
[ ] !pip install gmdh
    import gmdh
```

```
Requirement already satisfied: gmdh in /usr/local/lib/python3.10/dist-packages (1.0.3)
Requirement already satisfied: docstring-inheritance in /usr/local/lib/python3.10/dist-packages (from gmdh) (2.2.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from gmdh) (1.25.2)
```

```
!pip install sktime
from sklearn.metrics import mean_squared_error
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.holtwinters import ExponentialSmoothing
from sktime.datasets import load_airline
# Загрузка набора данных
al = load_airline()
al.info()

# Целочисленная метка шкалы времени
xnum = list(range(al.shape[0]))
# Разделение выборки на обучающую и тестовую
Y = al.values
train_size = int(len(Y) * 0.7)
xnum_train, xnum_test = xnum[0:train_size], xnum[train_size:]
train, test = Y[0:train_size], Y[train_size:]
history_arima = [x for x in train]
history_es = [x for x in train]
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
Requirement already satisfied: sktime in /usr/local/lib/python3.10/dist-packages (0.29.0)
Requirement already satisfied: numpy<1.27,>=1.21 in /usr/local/lib/python3.10/dist-packages (from sktime) (1.25.2)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from sktime) (24.0)
Requirement already satisfied: pandas<2.3.0,>=1.1 in /usr/local/lib/python3.10/dist-packages (from sktime) (2.0.3)
Requirement already satisfied: scikit-base<0.8.0,>=0.6.1 in /usr/local/lib/python3.10/dist-packages (from sktime) (0.7.7)
Requirement already satisfied: scikit-learn<1.5.0,>=0.24 in /usr/local/lib/python3.10/dist-packages (from sktime) (1.2.2)
Requirement already satisfied: scipy<2.0.0,>=1.2 in /usr/local/lib/python3.10/dist-packages (from sktime) (1.11.4)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.10/dist-packages (from pandas<2.3.0,>=1.1->sktime) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas<2.3.0,>=1.1->sktime) (2023.4)
Requirement already satisfied: tzdata>=2022.1 in /usr/local/lib/python3.10/dist-packages (from pandas<2.3.0,>=1.1->sktime) (2024.1)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn<1.5.0,>=0.24->sktime) (1.4.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn<1.5.0,>=0.24->sktime) (3.4.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2->pandas<2.3.0,>=1.1->sktime) (1.16.0)
Выходные данные были обрезаны до нескольких последних строк (5000).
<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _BokehImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _AltairImportHook.find_spec() not found; falling back to find_module()
```

```
[ ] from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_log_error, median_absolute_error, r2_score

    def print_metrics(y_test, y_pred, squared=False):
        print(f"R^2: {r2_score(y_test, y_pred)}")
        crit_name = "MSE" if squared else "RMSE"
        print(f"{crit_name}: {mean_squared_error(y_test, y_pred, squared=squared)}")
        print(f"MAE: {mean_absolute_error(y_test, y_pred)}")
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```

COMBI

```
# xnum_train, xnum_test = xnum[0:train_size], xnum[train_size:]
# train, test = Y[0:train_size], Y[train_size:]
combi_model = gmdh.Combi()
combi_model.fit(xnum_train, train, verbose=1, n_jobs=-1, test_size=0.24, limit=0,
                criterion=gmdh.Criterion(gmdh.CriterionType.REGULARITY))

print()
print(combi_model.get_best_polynomial())
print()
y_pred_combi = combi_model.predict(xnum_test)

print_metrics(test, y_pred_combi)
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
LEVEL 1  [========================] 100% [00m:00s] (1 combinations) error=69398.16782

y = 1.9626*x1 + 112.9815

R^2: -0.620205409345804
RMSE: 97.3066459642962
MAE: 73.50676256757596
```

```
[ ] import numpy as np
    import pandas as pd
    from matplotlib import pyplot
    import matplotlib.pyplot as plt

    plt.figure(figsize=(16,4))
    plt.plot(test, label="Actual")
    plt.plot(y_pred_combi, label="Predicted")
    plt.title('Time Series Forecasting', fontsize=20)
    plt.ylabel('Values', fontsize=16)
    plt.legend()
    plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
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<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
```

```
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
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<frozen importlib._bootstrap>:914: ImportWarning: _PyDriveImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _GenerativeAIImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: _OpenCVImportHook.find_spec() not found; falling back to find_module()
<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
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<frozen importlib._bootstrap>:914: ImportWarning: _PyDrive2ImportHook.find_spec() not found; falling back to find_module()
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<frozen importlib._bootstrap>:914: ImportWarning: APICoreClientInfoImportHook.find_spec() not found; falling back to find_module()
```

RIA

```
[ ] ria_model = gmdh.Ria()
    ria_model.fit(xnum_train, train, verbose=1, n_jobs=-1, test_size=0.52, limit=0, k_best=7,
                      criterion=gmdh.Criterion(gmdh.CriterionType.REGULARITY),
                      polynomial_type=gmdh.PolynomialType.LINEAR)
    y_pred_ria = ria_model.predict(xnum_test)
    print_metrics(test, y_pred_ria)
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the result to `transformed_cell` argument and
  and should_run_async(code)
```

```
[ ]
```