02.03-deep_learning

March 21, 2021

1 Deep Learning Model

Neste notebook tem os seguintes modelos de aprendizado de profundo comparados: - LSTM

1.1 Importações

[125]:
```
# Data analysis and data wrangling
import numpy as np
import pandas as pd

# Metrics
from sklearn.metrics import mean_squared_error

# Preprocessing
from sklearn.preprocessing import MinMaxScaler

# Plotting
import seaborn as sns
import matplotlib.pyplot as plt

# deep learning
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from keras.layers import Dropout
import tensorflow as tf

# Other
from IPython.display import Image
import warnings
import pprint
import datetime
import os
import datetime
```

1.2 Preparação do Diretório Principal

[126]:
```
def prepare_directory_work(end_directory: str='notebooks'):
    # Current path
    curr_dir = os.path.dirname (os.path.realpath ("__file__"))

    if curr_dir.endswith(end_directory):
        os.chdir('..')
        return curr_dir

    return f'Current working directory: {curr_dir}'
```

[127]:
```
prepare_directory_work(end_directory='notebooks')
```

[127]:
```
'Current working directory: /home/campos/projects/tcc'
```

1.3 Formatação das Células

[128]:
```
# OPTIONAL: Load the "autoreload" extension so that code can change
%load_ext autoreload

# Guarantees visualization inside the jupyter
%matplotlib inline

# Print xxxx rows and columns
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
pd.set_option('float_format', '{:f}'.format)

# Supress unnecessary warnings so that presentation looks clean
warnings.filterwarnings('ignore')

# pretty print
pp = pprint.PrettyPrinter(indent=4)
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

[129]:
```
plt.style.use('seaborn')  # fivethirtyeight
plt.rc('figure',figsize=(16,8))
plt.rc('font',size=15)
plt.rc('legend',fontsize=15)

# Seaborn rcParams
# ==================
sns.set(context='poster',  # notebook
        style='darkgrid',
```

```
        palette='deep',
        color_codes=True)

# graph style
sns.set(style='dark', palette='deep')

plt.style.use('fivethirtyeight')
```

1.4 Carregamento dos Dados

[130]:
```
%%time

df_vale3 = pd.read_csv('data/cleansing/df_vale3_cleansing.csv',
                       encoding='utf8',
                       delimiter=',',
                       parse_dates=True,
                       index_col=0,
                       verbose=True)
```

```
Tokenization took: 1.77 ms
Type conversion took: 2.29 ms
Parser memory cleanup took: 0.00 ms
CPU times: user 10.5 ms, sys: 283 µs, total: 10.7 ms
Wall time: 11 ms
```

[131]:
```
print(df_vale3.info())
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 2445 entries, 2010-07-12 to 2020-05-28
Data columns (total 9 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   preco         2445 non-null   float64
 1   residuos      2445 non-null   float64
 2   tendencia     2445 non-null   float64
 3   sazonalidade  2445 non-null   float64
 4   diff_1        2445 non-null   float64
 5   diff_2        2445 non-null   float64
 6   diff_3        2445 non-null   float64
 7   diff_4        2445 non-null   float64
 8   diff_5        2445 non-null   float64
dtypes: float64(9)
memory usage: 191.0 KB
None
```

[132]:
```
df_vale3.head()
```

[132]:

data	preco	residuos	tendencia	sazonalidade	diff_1	diff_2	diff_3	diff_4	diff_5
2010-07-12	40.000000	1.002310	41.827333	1.000149	-0.600000	-0.460000	0.490000	0.980000	0.420000
2010-07-13	40.070000	1.036654	41.910833	0.998563	0.070000	-0.530000	-0.390000	0.560000	1.050000
2010-07-14	40.080000	1.028377	41.977833	1.000439	0.010000	0.080000	-0.520000	-0.380000	0.570000
2010-07-15	39.760000	1.044658	42.045833	1.000935	-0.320000	-0.310000	-0.240000	-0.840000	-0.700000
2010-07-16	38.880000	1.028132	42.123500	1.001784	-0.880000	-1.200000	-1.190000	-1.120000	-1.720000

1.5 Divisão dos Dados

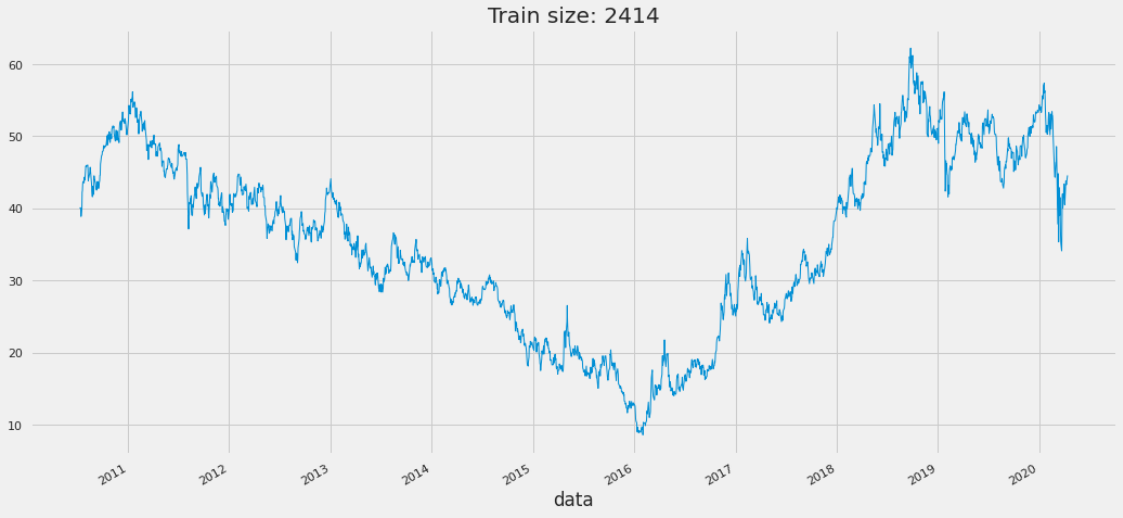
[133]:
```
size_train = 2414
size_test = 31
print(size_train)
print(size_test)

df_train = df_vale3.iloc[:size_train]
df_test = df_vale3.iloc[size_train:]
print(df_train.columns)
print(df_test.columns)
```

```
2414
31
Index(['preco', 'residuos', 'tendencia', 'sazonalidade', 'diff_1', 'diff_2',
       'diff_3', 'diff_4', 'diff_5'],
      dtype='object')
Index(['preco', 'residuos', 'tendencia', 'sazonalidade', 'diff_1', 'diff_2',
       'diff_3', 'diff_4', 'diff_5'],
      dtype='object')
```

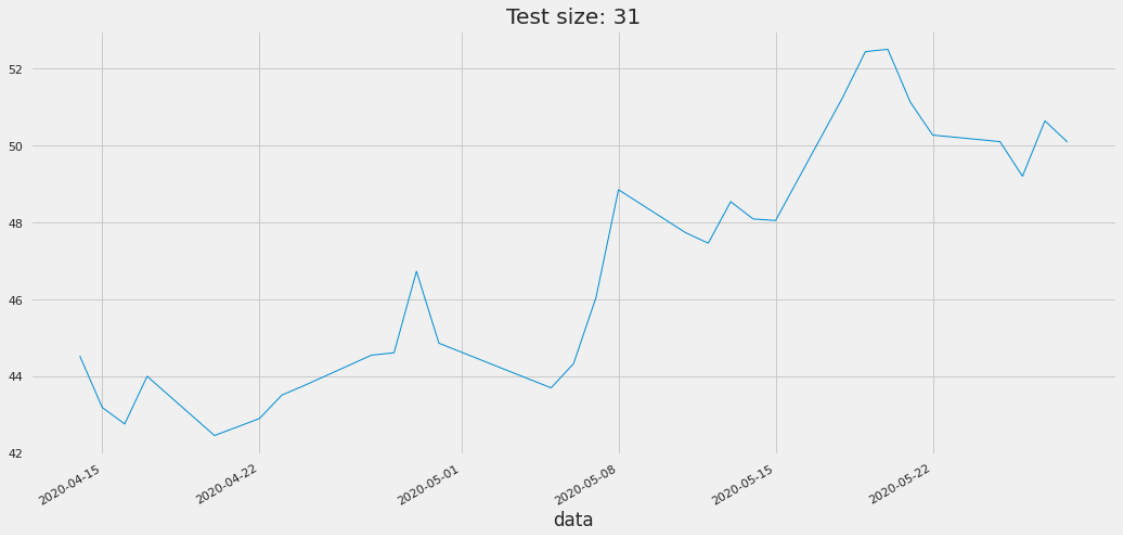
[134]:
```
df_train['preco'].plot(linewidth=1)
plt.grid(True)
plt.title(f'Train size: {len(df_train)}')
```

[134]:
```
Text(0.5, 1.0, 'Train size: 2414')
```



[135]:
```
df_test['preco'].plot(linewidth=1)
plt.grid(True)
plt.title(f'Test size: {len(df_test)}')
```

[135]: Text(0.5, 1.0, 'Test size: 31')



[136]:
```
df_train.index
```

[136]:
```
DatetimeIndex(['2010-07-12', '2010-07-13', '2010-07-14', '2010-07-15',
               '2010-07-16', '2010-07-19', '2010-07-20', '2010-07-21',
               '2010-07-22', '2010-07-23',
               …
```

```
               '2020-03-30', '2020-03-31', '2020-04-01', '2020-04-02',
               '2020-04-03', '2020-04-06', '2020-04-07', '2020-04-08',
               '2020-04-09', '2020-04-13'],
              dtype='datetime64[ns]', name='data', length=2414, freq=None)
```

[137]:
```
df_test.index
```

[137]:
```
DatetimeIndex(['2020-04-14', '2020-04-15', '2020-04-16', '2020-04-17',
               '2020-04-20', '2020-04-22', '2020-04-23', '2020-04-24',
               '2020-04-27', '2020-04-28', '2020-04-29', '2020-04-30',
               '2020-05-04', '2020-05-05', '2020-05-06', '2020-05-07',
               '2020-05-08', '2020-05-11', '2020-05-12', '2020-05-13',
               '2020-05-14', '2020-05-15', '2020-05-18', '2020-05-19',
               '2020-05-20', '2020-05-21', '2020-05-22', '2020-05-25',
               '2020-05-26', '2020-05-27', '2020-05-28'],
              dtype='datetime64[ns]', name='data', freq=None)
```

[138]:
```
# X_train = X_train[::-1]
# y_train = y_train[::-1]

# X_test = X_test[::-1]
# y_test = y_test[::-1]
```

1.6 Métrica de Avaliação

[139]:
```
def mean_absolute_percentage_error(y_true, y_pred):
    y_true, y_pred = np.array(y_true), np.array(y_pred)
    return np.mean(np.abs((y_true - y_pred) / y_true)) * 100
```

1.7 Dicionário de Resultados

[140]:
```
dict_results = {}
```

1.8 Impressão dos Resutados

[141]:
```
def show_result_model(df_train, df_test, y_forecast, model_name):
    future_forecast = pd.DataFrame(y_forecast,
                                   index=df_test.index,
                                   columns=['previsao'])
    mape = mean_absolute_percentage_error(df_test, y_forecast)
    mse = mean_squared_error(df_test, y_forecast, squared=True)
    dict_results[model_name] = [mape, mse]
```

```
    pd.concat([df_train, df_test, future_forecast], axis=1).plot()

    plt.legend()
    plt.grid(True)
    plt.xlabel("Tempo (dias)", fontsize=20)
    plt.ylabel("Preço (R$)", fontsize=20)
    plt.title(f'MAPE = {mape:.2f} % | MSE = {mse:.2f}', fontsize=25)
```

1.9 Normalização dos Dados

[142]:
```
train_max = df_train.max()
train_min = df_train.min()

train = (df_train - train_min)/(train_max - train_min)
test = (df_test - train_min)/(train_max - train_min)
```

[143]:
```
def create_dataset(X, y, time_steps=1):
    Xs, ys = [], []

    for i in range(len(X) - time_steps):
        v = X.iloc[i:(i + time_steps)].values
        Xs.append(v)
        ys.append(y.iloc[i + time_steps])

    return np.array(Xs).astype('float32'), np.array(ys).astype('float32')
```

[144]:
```
time_steps = 1

X_train, y_train = create_dataset(train, train['preco'], time_steps)
X_test, y_test = create_dataset(test, test['preco'], time_steps)
```

1.10 LSTM

[145]:
```
# sequential model
model_lstm = Sequential(name='lstm_vale3')
model_lstm
```

[145]:
```
<tensorflow.python.keras.engine.sequential.Sequential at 0x7fbc87c655b0>
```

Input Layer

[146]:
```
#Adding the first LSTM layer and some Dropout regularisation
model_lstm.add(LSTM(units=50, return_sequences=True, input_shape=(X_train.
 ↪shape[1], X_train.shape[2])))
model_lstm.add(Dropout(0.2))
```

Hidden Layers

[147]:
```
# Adding a second LSTM layer and some Dropout regularisation
model_lstm.add(LSTM(units=50, return_sequences=True))
model_lstm.add(Dropout(0.2))

# Adding a third LSTM layer and some Dropout regularisation
model_lstm.add(LSTM(units=50, return_sequences=True))
model_lstm.add(Dropout(0.2))

# Adding a fourth LSTM layer and some Dropout regularisation
model_lstm.add(LSTM(units=50))
model_lstm.add(Dropout(0.2))
```

Output Layer

[148]:
```
model_lstm.add(Dense(units=1))
```

1.10.1 Compilação da RNA

[149]:
```
model_lstm.compile(loss='mean_squared_error',
                   optimizer='adam',
                   metrics=['accuracy'])
```

1.10.2 Resumo da RNA

[150]:
```
model_lstm.summary()
```

```
Model: "lstm_vale3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_12 (LSTM)               (None, 1, 50)             12000
_________________________________________________________________
dropout_12 (Dropout)         (None, 1, 50)             0
_________________________________________________________________
lstm_13 (LSTM)               (None, 1, 50)             20200
_________________________________________________________________
dropout_13 (Dropout)         (None, 1, 50)             0
_________________________________________________________________
lstm_14 (LSTM)               (None, 1, 50)             20200
_________________________________________________________________
```

```
dropout_14 (Dropout)         (None, 1, 50)             0
_________________________________________________________________
lstm_15 (LSTM)               (None, 50)                20200
_________________________________________________________________
dropout_15 (Dropout)         (None, 50)                0
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 51
=================================================================
Total params: 72,651
Trainable params: 72,651
Non-trainable params: 0
_________________________________________________________________
```

1.11 Treinamento

- batch_size: cria lote de treinamento de 30 em 30 dias

[151]:
```
%%time


history = model_lstm.fit(X_train,
                y_train,
                epochs=1000,
                batch_size=30,
                shuffle=False,
                validation_split=0.10,
                verbose=0)
history
```

```
CPU times: user 18min 39s, sys: 2min 33s, total: 21min 13s
Wall time: 8min 58s
```

[151]:
```
<tensorflow.python.keras.callbacks.History at 0x7fbc8798a2e0>
```

[152]:
```
print(history.history.keys())
```

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

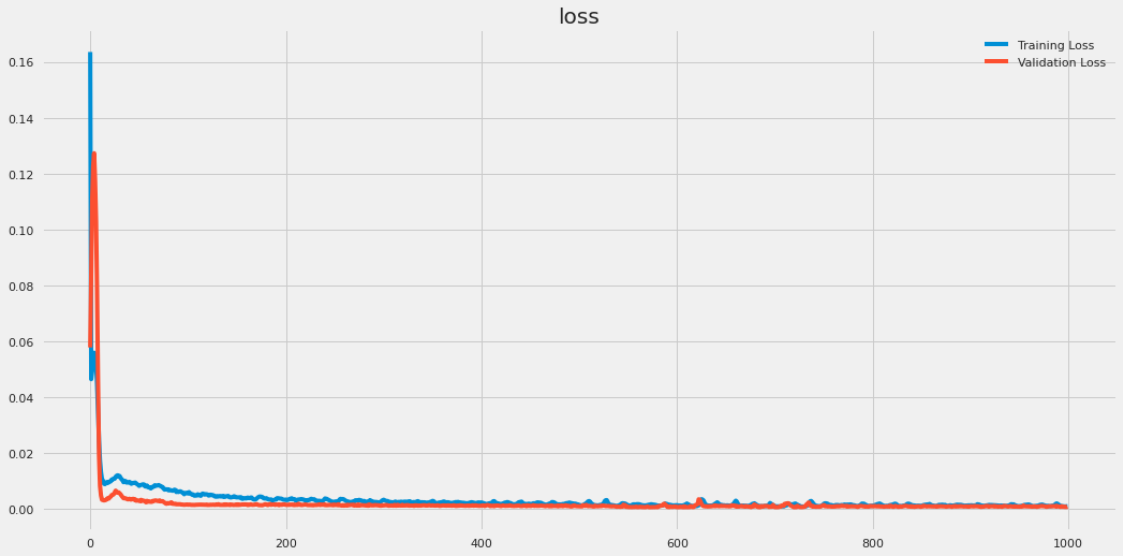
[153]:
```
best_epochs = history.history["loss"].index(min(history.history["loss"]))
best_epochs
```

[153]:
```
727
```

[154]:
```
min(history.history["loss"])
```

[154]:
```
0.0008026042487472296
```

[155]:
```
plt.plot(history.history["loss"], label="Training Loss")
plt.plot(history.history["val_loss"], label="Validation Loss")
plt.title('loss')
plt.legend()
plt.show()
```



1.11.1 Predict

[156]:
```
y_pred = model_lstm.predict(X_test)
```

[157]:
```
# Rescale the data back to the original scale
y_test = y_test*(train_max[0] - train_min[0]) + train_min[0]
y_pred = y_pred*(train_max[0] - train_min[0]) + train_min[0]
y_train = y_train*(train_max[0] - train_min[0]) + train_min[0]
```

[158]:
```
y_test[:10]
```

[158]:
```
array([43.189995, 42.760002, 44.      , 42.46    , 42.9     , 43.510002,
       43.760002, 44.550003, 44.61    , 46.729996], dtype=float32)
```

[159]:
```
len(y_test)
```

[159]: 30

[160]:
```
y_train[:10]
```

[160]:
```
array([40.07    , 40.079998, 39.760002, 38.879997, 39.969997, 42.229996,
       42.47    , 43.370003, 43.71    , 43.730003], dtype=float32)
```

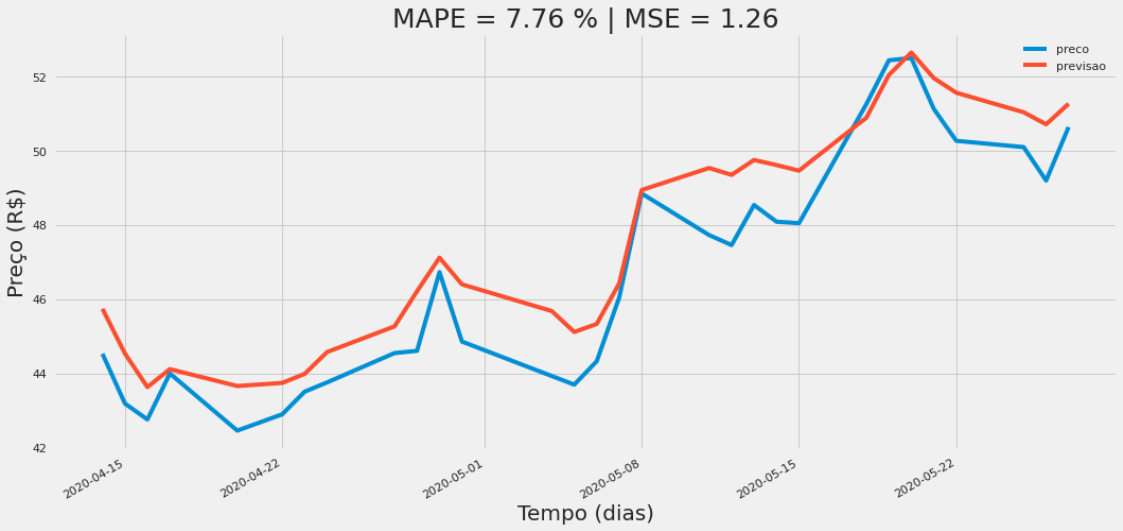
[161]:
```
mean_absolute_percentage_error(df_test['preco'][:30], y_pred)
```

[161]:
```
7.760199706168364
```

[162]:
```
mean_absolute_percentage_error(y_test, y_pred)
```

[162]:
```
7.718035578727722
```

[163]:
```
show_result_model(df_train=df_test['preco'][:30],
                  df_test=df_test['preco'][:30],
                  y_forecast=y_pred,
                  model_name='model_lstm')
```



1.12 Results

[164]:
```
dict_results
```

[164]:
```
{'model_lstm': [7.760199706168364, 1.2631785989134543]}
```
