NO2_RNN2-Copy1

November 30, 2017

In [1]:
```
import numpy as np
import pandas as pd
import os
import matplotlib.pyplot as plt

import tensorflow as tf
from keras.backend.tensorflow_backend import set_session
config = tf.ConfigProto()
config.gpu_options.per_process_gpu_memory_fraction = 0.3
set_session(tf.Session(config=config))
```

```
Using TensorFlow backend.
```

In [2]:
```
os.listdir('data')
```

Out[2]:
```
['AllNO2_QH.csv',
 'AllPM_QH.csv',
 'Env_QH.csv',
 'GradientTemp_15minDataSet.csv',
 'micro_sud3.pkl',
 'micro_sud3_normalized.pkl',
 'Patm_15minDataSet.csv',
 'pickles']
```

In [3]:
```
df = pd.read_pickle('data/micro_sud3_normalized.pkl')
df = df.reset_index()

def split_dataframe(dataframe, percent):
    nb_rows = int(np.floor(percent * len(dataframe)))
    return dataframe[:nb_rows], dataframe[nb_rows:]

def dataframe_to_xy(df, look_back):
    i = look_back
    while True:
        sequence = df.iloc[i - look_back:i]
        yield np.array(sequence[['NO2_61FD', 'NO2_61F0', 'NO2_61EF', 'temp', 'rh',\
                                 'tgrad', 'pressure', 'pluvio']]).reshape(look_back, 1
```

```
            i += 1
            if i == len(df):
                i = look_back

    def dataframe_to_xy_test(df, look_back):
        X_test, y_test = [], []
        i = look_back
        while i < len(df):
            sequence = df.iloc[i - look_back:i]
            X_test.append(np.array(sequence[['NO2_61FD', 'NO2_61F0', 'NO2_61EF', 'temp', '
                                        'tgrad', 'pressure', 'pluvio']]).reshape(look_back, 1
            y_test.append(np.array(df.iloc[i]['NO2_ref']))
            i += 1
            if i == len(df):
                break

        return np.array(X_test), np.array(y_test)


    df_test, df_train = split_dataframe(df, 0.5)
    df_valid, df_test = split_dataframe(df_test, 0.5)

    X_train = dataframe_to_xy(df_train, 10)
    X_valid = dataframe_to_xy(df_valid, 10)
    X_test, y_test = dataframe_to_xy_test(df_test, 10)
```

In [4]:
```
def dataframe_to_xy_no_generator(df, look_back):
    X, y = [], []
    i = look_back
    while i < len(df):
        sequence = df.iloc[i - look_back:i]
        X.append(np.array(sequence[['NO2_61FD', 'NO2_61F0', 'NO2_61EF', 'temp', 'rh',\
                                    'tgrad', 'pressure', 'pluvio']]).reshape(look_back, 1
        y.append(np.array(df.iloc[i]['NO2_ref']))
        i += 1
        if i == len(df):
            break
    X = np.array(X)
    y = np.array(y)
    X = X.reshape((X.shape[0], X.shape[1], X.shape[3]))
    return X, y
```

In [5]:
```
X_train, y_train = dataframe_to_xy_no_generator(df_train, 24)
X_valid, y_valid = dataframe_to_xy_no_generator(df_valid, 24)
X_test, y_test = dataframe_to_xy_no_generator(df_test, 24)
```

In [6]:
```
from keras.layers import SimpleRNN, Dense, LSTM, GRU
from keras.models import Sequential
```

```
        from keras.callbacks import EarlyStopping

        def simple_rnn_model(nb_units, input_dim, loss='mean_squared_error', optimizer='adam'):
            model = Sequential()
            model.add(SimpleRNN(nb_units, input_shape=input_dim))
            model.add(Dense(nb_units, activation='relu'))
            model.add(Dense(1, kernel_initializer='normal'))
            model.compile(loss=loss, optimizer=optimizer)
            model.summary()
            return model

        def lstm_model(nb_units, input_dim, loss='mean_squared_error', optimizer='adam'):
            model = Sequential()
            model.add(LSTM(nb_units, input_shape=input_dim))
            model.add(Dense(nb_units, activation='relu'))
            model.add(Dense(1, kernel_initializer='normal'))
            model.compile(loss=loss, optimizer=optimizer)
            model.summary()
            return model

        def gru_model(nb_units, input_dim, loss='mean_squared_error', optimizer='adam'):
            model = Sequential()
            model.add(GRU(nb_units, input_shape=input_dim))
            model.add(Dense(nb_units, activation='relu'))
            model.add(Dense(1, kernel_initializer='normal'))
            model.compile(loss=loss, optimizer=optimizer)
            model.summary()
            return model

In [7]: model = simple_rnn_model(32, X_train.shape[1:])

_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
simple_rnn_1 (SimpleRNN)     (None, 32)                1312
_________________________________________________________________
dense_1 (Dense)              (None, 32)                1056
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 33
=================================================================
Total params: 2,401
Trainable params: 2,401
Non-trainable params: 0
_________________________________________________________________


In [8]: early_stopping = EarlyStopping(monitor='val_loss', verbose=1, mode='auto', patience=10)
        history = model.fit(X_train, y_train, batch_size=32, epochs=5000, validation_data=(X_va
```

```
Train on 1103 samples, validate on 539 samples
Epoch 1/5000
1103/1103 [==============================] - 1s 475us/step - loss: 2151.4970 - val_loss: 2757.
Epoch 2/5000
1103/1103 [==============================] - 0s 129us/step - loss: 2119.9496 - val_loss: 2708.
Epoch 3/5000
1103/1103 [==============================] - 0s 129us/step - loss: 2051.8058 - val_loss: 2591.
Epoch 4/5000
1103/1103 [==============================] - 0s 129us/step - loss: 1914.1495 - val_loss: 2374.
Epoch 5/5000
1103/1103 [==============================] - 0s 128us/step - loss: 1695.9594 - val_loss: 2081.
Epoch 6/5000
1103/1103 [==============================] - 0s 129us/step - loss: 1452.6277 - val_loss: 1783.
Epoch 7/5000
1103/1103 [==============================] - 0s 128us/step - loss: 1221.8381 - val_loss: 1552.
Epoch 8/5000
1103/1103 [==============================] - 0s 126us/step - loss: 1073.7127 - val_loss: 1395.
Epoch 9/5000
1103/1103 [==============================] - 0s 129us/step - loss: 982.9393 - val_loss: 1301.5
Epoch 10/5000
1103/1103 [==============================] - 0s 130us/step - loss: 930.4325 - val_loss: 1242.5
Epoch 11/5000
1103/1103 [==============================] - 0s 129us/step - loss: 896.8419 - val_loss: 1204.0
Epoch 12/5000
1103/1103 [==============================] - 0s 128us/step - loss: 873.7001 - val_loss: 1176.9
Epoch 13/5000
1103/1103 [==============================] - 0s 128us/step - loss: 856.4284 - val_loss: 1153.9
Epoch 14/5000
1103/1103 [==============================] - 0s 130us/step - loss: 843.2439 - val_loss: 1137.5
Epoch 15/5000
1103/1103 [==============================] - 0s 128us/step - loss: 831.6016 - val_loss: 1124.3
Epoch 16/5000
1103/1103 [==============================] - 0s 127us/step - loss: 821.3215 - val_loss: 1113.0
Epoch 17/5000
1103/1103 [==============================] - 0s 127us/step - loss: 812.9621 - val_loss: 1100.2
Epoch 18/5000
1103/1103 [==============================] - 0s 129us/step - loss: 805.1434 - val_loss: 1088.5
Epoch 19/5000
1103/1103 [==============================] - 0s 129us/step - loss: 797.0758 - val_loss: 1077.5
Epoch 20/5000
1103/1103 [==============================] - 0s 128us/step - loss: 789.2102 - val_loss: 1063.4
Epoch 21/5000
1103/1103 [==============================] - 0s 130us/step - loss: 780.4834 - val_loss: 1053.0
Epoch 22/5000
1103/1103 [==============================] - 0s 128us/step - loss: 770.1945 - val_loss: 1045.5
Epoch 23/5000
1103/1103 [==============================] - 0s 128us/step - loss: 762.1672 - val_loss: 1034.7
Epoch 24/5000
```

```
1103/1103 [==============================] - 0s 128us/step - loss: 751.5105 - val_loss: 1021.45
Epoch 25/5000
1103/1103 [==============================] - 0s 129us/step - loss: 740.8569 - val_loss: 1014.83
Epoch 26/5000
1103/1103 [==============================] - 0s 129us/step - loss: 732.0826 - val_loss: 1013.63
Epoch 27/5000
1103/1103 [==============================] - 0s 130us/step - loss: 721.7421 - val_loss: 985.355
Epoch 28/5000
1103/1103 [==============================] - 0s 129us/step - loss: 725.4690 - val_loss: 977.508
Epoch 29/5000
1103/1103 [==============================] - 0s 131us/step - loss: 703.8999 - val_loss: 966.547
Epoch 30/5000
1103/1103 [==============================] - 0s 134us/step - loss: 694.4027 - val_loss: 944.700
Epoch 31/5000
1103/1103 [==============================] - 0s 130us/step - loss: 675.6985 - val_loss: 914.253
Epoch 32/5000
1103/1103 [==============================] - 0s 131us/step - loss: 665.0832 - val_loss: 886.983
Epoch 33/5000
1103/1103 [==============================] - 0s 133us/step - loss: 650.4654 - val_loss: 862.285
Epoch 34/5000
1103/1103 [==============================] - 0s 128us/step - loss: 617.3223 - val_loss: 829.190
Epoch 35/5000
1103/1103 [==============================] - 0s 129us/step - loss: 604.7086 - val_loss: 796.840
Epoch 36/5000
1103/1103 [==============================] - 0s 129us/step - loss: 582.3427 - val_loss: 754.402
Epoch 37/5000
1103/1103 [==============================] - 0s 131us/step - loss: 553.0076 - val_loss: 746.699
Epoch 38/5000
1103/1103 [==============================] - 0s 128us/step - loss: 540.4326 - val_loss: 700.798
Epoch 39/5000
1103/1103 [==============================] - 0s 131us/step - loss: 520.2627 - val_loss: 670.974
Epoch 40/5000
1103/1103 [==============================] - 0s 128us/step - loss: 499.9752 - val_loss: 651.633
Epoch 41/5000
1103/1103 [==============================] - 0s 130us/step - loss: 483.4526 - val_loss: 612.142
Epoch 42/5000
1103/1103 [==============================] - 0s 130us/step - loss: 463.4750 - val_loss: 592.812
Epoch 43/5000
1103/1103 [==============================] - 0s 129us/step - loss: 442.7821 - val_loss: 560.352
Epoch 44/5000
1103/1103 [==============================] - 0s 131us/step - loss: 425.3795 - val_loss: 535.332
Epoch 45/5000
1103/1103 [==============================] - 0s 130us/step - loss: 411.5432 - val_loss: 510.765
Epoch 46/5000
1103/1103 [==============================] - 0s 131us/step - loss: 403.0894 - val_loss: 498.354
Epoch 47/5000
1103/1103 [==============================] - 0s 132us/step - loss: 391.3792 - val_loss: 497.417
Epoch 48/5000
```

```
1103/1103 [==============================] - 0s 128us/step - loss: 369.1000 - val_loss: 466.307
Epoch 49/5000
1103/1103 [==============================] - 0s 131us/step - loss: 353.5924 - val_loss: 446.585
Epoch 50/5000
1103/1103 [==============================] - 0s 130us/step - loss: 345.3276 - val_loss: 435.215
Epoch 51/5000
1103/1103 [==============================] - 0s 129us/step - loss: 342.2949 - val_loss: 434.287
Epoch 52/5000
1103/1103 [==============================] - 0s 130us/step - loss: 334.3286 - val_loss: 419.784
Epoch 53/5000
1103/1103 [==============================] - 0s 131us/step - loss: 330.0714 - val_loss: 410.114
Epoch 54/5000
1103/1103 [==============================] - 0s 129us/step - loss: 322.3000 - val_loss: 388.955
Epoch 55/5000
1103/1103 [==============================] - 0s 126us/step - loss: 312.5661 - val_loss: 383.589
Epoch 56/5000
1103/1103 [==============================] - 0s 128us/step - loss: 303.3627 - val_loss: 373.385
Epoch 57/5000
1103/1103 [==============================] - 0s 128us/step - loss: 296.7394 - val_loss: 360.148
Epoch 58/5000
1103/1103 [==============================] - 0s 128us/step - loss: 298.7776 - val_loss: 358.254
Epoch 59/5000
1103/1103 [==============================] - 0s 127us/step - loss: 286.9637 - val_loss: 348.839
Epoch 60/5000
1103/1103 [==============================] - 0s 128us/step - loss: 285.9655 - val_loss: 351.808
Epoch 61/5000
1103/1103 [==============================] - 0s 128us/step - loss: 281.6230 - val_loss: 342.368
Epoch 62/5000
1103/1103 [==============================] - 0s 128us/step - loss: 292.1921 - val_loss: 382.036
Epoch 63/5000
1103/1103 [==============================] - 0s 129us/step - loss: 295.8204 - val_loss: 352.192
Epoch 64/5000
1103/1103 [==============================] - 0s 131us/step - loss: 296.0821 - val_loss: 362.708
Epoch 65/5000
1103/1103 [==============================] - 0s 128us/step - loss: 282.1966 - val_loss: 360.806
Epoch 66/5000
1103/1103 [==============================] - 0s 128us/step - loss: 274.2797 - val_loss: 349.675
Epoch 67/5000
1103/1103 [==============================] - 0s 129us/step - loss: 267.3367 - val_loss: 356.759
Epoch 68/5000
1103/1103 [==============================] - 0s 128us/step - loss: 255.6794 - val_loss: 350.959
Epoch 69/5000
1103/1103 [==============================] - 0s 129us/step - loss: 252.8888 - val_loss: 346.048
Epoch 70/5000
1103/1103 [==============================] - 0s 130us/step - loss: 243.3546 - val_loss: 336.021
Epoch 71/5000
1103/1103 [==============================] - 0s 128us/step - loss: 237.9458 - val_loss: 335.755
Epoch 72/5000
```

```
1103/1103 [==============================] - 0s 129us/step - loss: 237.5304 - val_loss: 335.313
Epoch 73/5000
1103/1103 [==============================] - 0s 129us/step - loss: 230.9491 - val_loss: 336.130
Epoch 74/5000
1103/1103 [==============================] - 0s 131us/step - loss: 228.3761 - val_loss: 334.999
Epoch 75/5000
1103/1103 [==============================] - 0s 127us/step - loss: 225.1395 - val_loss: 329.225
Epoch 76/5000
1103/1103 [==============================] - 0s 126us/step - loss: 220.5830 - val_loss: 325.829
Epoch 77/5000
1103/1103 [==============================] - 0s 127us/step - loss: 218.4271 - val_loss: 324.961
Epoch 78/5000
1103/1103 [==============================] - 0s 127us/step - loss: 217.0154 - val_loss: 323.283
Epoch 79/5000
1103/1103 [==============================] - 0s 125us/step - loss: 214.6310 - val_loss: 319.337
Epoch 80/5000
1103/1103 [==============================] - 0s 128us/step - loss: 211.8939 - val_loss: 317.452
Epoch 81/5000
1103/1103 [==============================] - 0s 127us/step - loss: 210.0510 - val_loss: 316.493
Epoch 82/5000
1103/1103 [==============================] - 0s 127us/step - loss: 208.5327 - val_loss: 316.497
Epoch 83/5000
1103/1103 [==============================] - 0s 126us/step - loss: 207.1725 - val_loss: 314.110
Epoch 84/5000
1103/1103 [==============================] - 0s 128us/step - loss: 205.3503 - val_loss: 312.571
Epoch 85/5000
1103/1103 [==============================] - 0s 128us/step - loss: 204.1305 - val_loss: 310.912
Epoch 86/5000
1103/1103 [==============================] - 0s 127us/step - loss: 202.8102 - val_loss: 313.164
Epoch 87/5000
1103/1103 [==============================] - 0s 126us/step - loss: 202.2700 - val_loss: 307.006
Epoch 88/5000
1103/1103 [==============================] - 0s 127us/step - loss: 203.3300 - val_loss: 306.845
Epoch 89/5000
1103/1103 [==============================] - 0s 137us/step - loss: 199.9084 - val_loss: 309.121
Epoch 90/5000
1103/1103 [==============================] - 0s 132us/step - loss: 199.2476 - val_loss: 306.320
Epoch 91/5000
1103/1103 [==============================] - 0s 127us/step - loss: 202.3048 - val_loss: 314.481
Epoch 92/5000
1103/1103 [==============================] - 0s 125us/step - loss: 200.5429 - val_loss: 301.720
Epoch 93/5000
1103/1103 [==============================] - 0s 128us/step - loss: 198.3355 - val_loss: 299.240
Epoch 94/5000
1103/1103 [==============================] - 0s 126us/step - loss: 195.3091 - val_loss: 301.923
Epoch 95/5000
1103/1103 [==============================] - 0s 127us/step - loss: 195.0886 - val_loss: 300.789
Epoch 96/5000
```

```
1103/1103 [==============================] - 0s 128us/step - loss: 193.1802 - val_loss: 293.910
Epoch 97/5000
1103/1103 [==============================] - 0s 126us/step - loss: 191.9796 - val_loss: 296.797
Epoch 98/5000
1103/1103 [==============================] - 0s 128us/step - loss: 190.7419 - val_loss: 293.401
Epoch 99/5000
1103/1103 [==============================] - 0s 128us/step - loss: 189.7211 - val_loss: 291.302
Epoch 100/5000
1103/1103 [==============================] - 0s 132us/step - loss: 189.6751 - val_loss: 287.336
Epoch 101/5000
1103/1103 [==============================] - 0s 131us/step - loss: 188.9332 - val_loss: 291.950
Epoch 102/5000
1103/1103 [==============================] - 0s 126us/step - loss: 192.7483 - val_loss: 291.799
Epoch 103/5000
1103/1103 [==============================] - 0s 127us/step - loss: 192.5432 - val_loss: 289.682
Epoch 104/5000
1103/1103 [==============================] - 0s 127us/step - loss: 187.0909 - val_loss: 289.867
Epoch 105/5000
1103/1103 [==============================] - 0s 128us/step - loss: 200.0407 - val_loss: 298.696
Epoch 106/5000
1103/1103 [==============================] - 0s 128us/step - loss: 208.2110 - val_loss: 295.103
Epoch 107/5000
1103/1103 [==============================] - 0s 127us/step - loss: 201.1527 - val_loss: 295.657
Epoch 108/5000
1103/1103 [==============================] - 0s 128us/step - loss: 198.0726 - val_loss: 288.853
Epoch 109/5000
1103/1103 [==============================] - 0s 127us/step - loss: 193.9840 - val_loss: 282.198
Epoch 110/5000
1103/1103 [==============================] - 0s 127us/step - loss: 217.6653 - val_loss: 279.115
Epoch 111/5000
1103/1103 [==============================] - 0s 128us/step - loss: 212.2421 - val_loss: 282.441
Epoch 112/5000
1103/1103 [==============================] - 0s 130us/step - loss: 209.7903 - val_loss: 285.521
Epoch 113/5000
1103/1103 [==============================] - 0s 129us/step - loss: 200.5288 - val_loss: 295.768
Epoch 114/5000
1103/1103 [==============================] - 0s 130us/step - loss: 197.8617 - val_loss: 280.876
Epoch 115/5000
1103/1103 [==============================] - 0s 129us/step - loss: 190.5344 - val_loss: 280.760
Epoch 116/5000
1103/1103 [==============================] - 0s 127us/step - loss: 189.6546 - val_loss: 283.098
Epoch 117/5000
1103/1103 [==============================] - 0s 128us/step - loss: 187.5609 - val_loss: 288.073
Epoch 118/5000
1103/1103 [==============================] - 0s 127us/step - loss: 188.8359 - val_loss: 288.983
Epoch 119/5000
1103/1103 [==============================] - 0s 127us/step - loss: 184.2258 - val_loss: 286.232
Epoch 120/5000
```

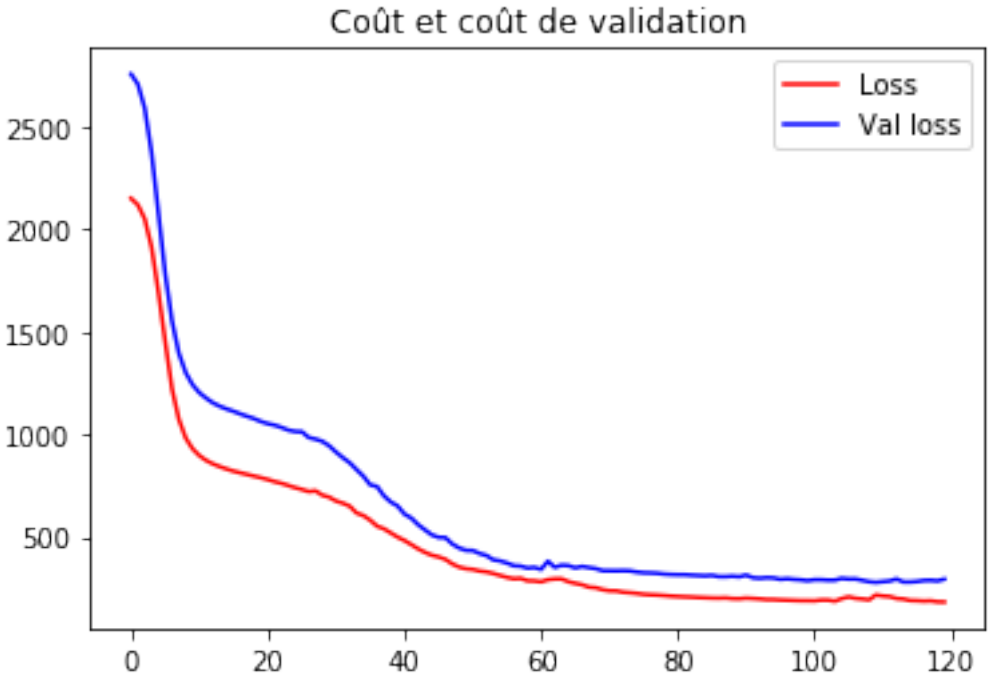
```
1103/1103 [==============================] - 0s 129us/step - loss: 183.3785 - val_loss: 294.627
Epoch 00120: early stopping
```

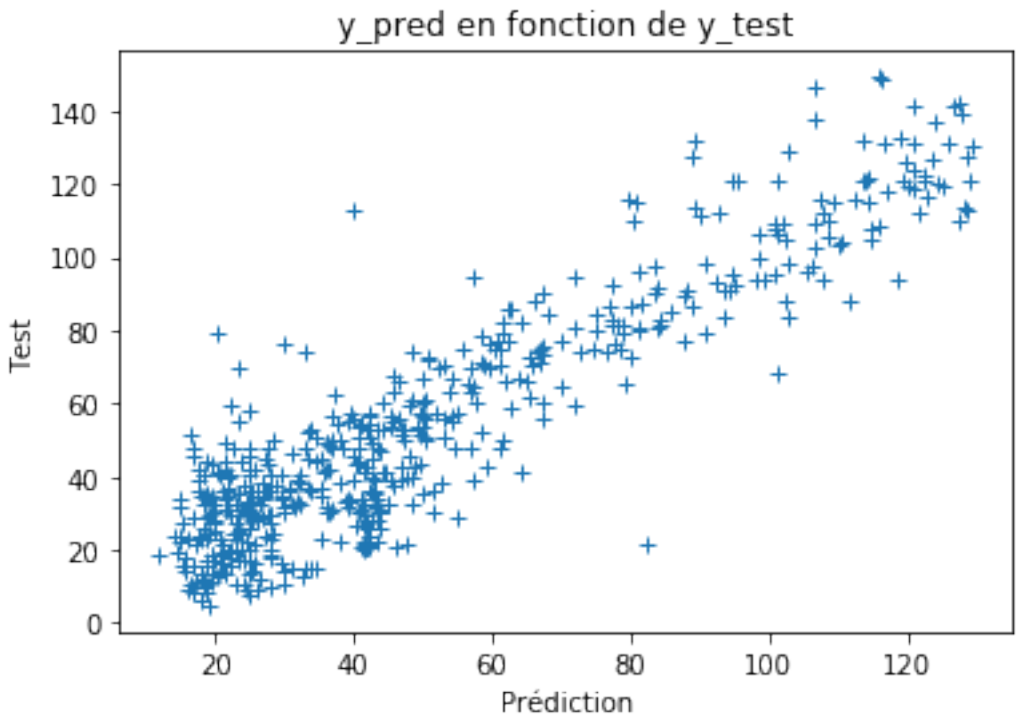
In [9]:
```
y_pred = model.predict(X_test)
plt.title('Coût et coût de validation')
line1,=plt.plot(history.history['loss'], label="Loss", linestyle='-', color='r')
line2,=plt.plot(history.history['val_loss'], label="Val loss", linestyle='-', color='b
first_legend = plt.legend(handles=[line1, line2], loc=1)

plt.show()

plt.title('y_pred en fonction de y_test')

plt.plot(y_pred[:], y_test[:], '+')
plt.ylabel('Test')
plt.xlabel('Prédiction')
plt.show()
```






```
In [10]: model = lstm_model(32, X_train.shape[1:])

_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 32)                5248
_________________________________________________________________
dense_3 (Dense)              (None, 32)                1056
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 33
=================================================================
Total params: 6,337
Trainable params: 6,337
Non-trainable params: 0
_________________________________________________________________
```

```
In [11]: early_stopping = EarlyStopping(monitor='val_loss', verbose=1, mode='auto', patience=1
         history = model.fit(X_train, y_train, batch_size=32, epochs=5000, validation_data=(X_

Train on 1103 samples, validate on 539 samples
Epoch 1/5000
1103/1103 [==============================] - 1s 1ms/step - loss: 2158.1391 - val_loss: 2773.91
Epoch 2/5000
```

```
1103/1103 [==============================] - 0s 433us/step - loss: 2139.1705 - val_loss: 2739.3
Epoch 3/5000
1103/1103 [==============================] - 0s 426us/step - loss: 2075.6451 - val_loss: 2616.0
Epoch 4/5000
1103/1103 [==============================] - 0s 428us/step - loss: 1881.1780 - val_loss: 2295.7
Epoch 5/5000
1103/1103 [==============================] - 0s 424us/step - loss: 1505.9102 - val_loss: 1758.8
Epoch 6/5000
1103/1103 [==============================] - 0s 425us/step - loss: 1106.6164 - val_loss: 1340.8
Epoch 7/5000
1103/1103 [==============================] - 0s 424us/step - loss: 925.6381 - val_loss: 1199.74
Epoch 8/5000
1103/1103 [==============================] - 0s 423us/step - loss: 860.5972 - val_loss: 1145.48
Epoch 9/5000
1103/1103 [==============================] - 0s 430us/step - loss: 835.6748 - val_loss: 1118.90
Epoch 10/5000
1103/1103 [==============================] - 0s 434us/step - loss: 820.3990 - val_loss: 1098.31
Epoch 11/5000
1103/1103 [==============================] - 0s 424us/step - loss: 805.0336 - val_loss: 1075.88
Epoch 12/5000
1103/1103 [==============================] - 0s 425us/step - loss: 782.5733 - val_loss: 1044.29
Epoch 13/5000
1103/1103 [==============================] - 0s 428us/step - loss: 752.6392 - val_loss: 1002.21
Epoch 14/5000
1103/1103 [==============================] - 0s 431us/step - loss: 723.7335 - val_loss: 961.642
Epoch 15/5000
1103/1103 [==============================] - 0s 426us/step - loss: 690.0417 - val_loss: 921.246
Epoch 16/5000
1103/1103 [==============================] - 0s 430us/step - loss: 655.3645 - val_loss: 877.097
Epoch 17/5000
1103/1103 [==============================] - 0s 428us/step - loss: 615.3997 - val_loss: 825.177
Epoch 18/5000
1103/1103 [==============================] - 0s 433us/step - loss: 564.0900 - val_loss: 756.524
Epoch 19/5000
1103/1103 [==============================] - 0s 435us/step - loss: 507.3731 - val_loss: 682.054
Epoch 20/5000
1103/1103 [==============================] - 0s 429us/step - loss: 461.8254 - val_loss: 621.620
Epoch 21/5000
1103/1103 [==============================] - 0s 430us/step - loss: 423.7758 - val_loss: 577.326
Epoch 22/5000
1103/1103 [==============================] - 0s 431us/step - loss: 394.3307 - val_loss: 523.496
Epoch 23/5000
1103/1103 [==============================] - 0s 430us/step - loss: 370.3444 - val_loss: 487.734
Epoch 24/5000
1103/1103 [==============================] - 0s 429us/step - loss: 346.5043 - val_loss: 449.473
Epoch 25/5000
1103/1103 [==============================] - 0s 427us/step - loss: 328.3972 - val_loss: 435.100
Epoch 26/5000
```

```
1103/1103 [==============================] - 0s 432us/step - loss: 317.9360 - val_loss: 388.374
Epoch 27/5000
1103/1103 [==============================] - 0s 426us/step - loss: 303.1529 - val_loss: 366.823
Epoch 28/5000
1103/1103 [==============================] - 0s 430us/step - loss: 290.3950 - val_loss: 349.545
Epoch 29/5000
1103/1103 [==============================] - 0s 429us/step - loss: 283.1105 - val_loss: 337.560
Epoch 30/5000
1103/1103 [==============================] - 0s 433us/step - loss: 273.5179 - val_loss: 321.671
Epoch 31/5000
1103/1103 [==============================] - 0s 442us/step - loss: 262.6717 - val_loss: 314.783
Epoch 32/5000
1103/1103 [==============================] - 0s 433us/step - loss: 255.7837 - val_loss: 305.024
Epoch 33/5000
1103/1103 [==============================] - 0s 432us/step - loss: 246.8965 - val_loss: 297.426
Epoch 34/5000
1103/1103 [==============================] - 0s 431us/step - loss: 239.5915 - val_loss: 288.958
Epoch 35/5000
1103/1103 [==============================] - 0s 433us/step - loss: 234.1403 - val_loss: 290.578
Epoch 36/5000
1103/1103 [==============================] - 0s 437us/step - loss: 229.0104 - val_loss: 278.557
Epoch 37/5000
1103/1103 [==============================] - 0s 433us/step - loss: 222.9263 - val_loss: 281.901
Epoch 38/5000
1103/1103 [==============================] - 0s 432us/step - loss: 218.1088 - val_loss: 280.913
Epoch 39/5000
1103/1103 [==============================] - 0s 427us/step - loss: 215.4153 - val_loss: 283.528
Epoch 40/5000
1103/1103 [==============================] - 0s 415us/step - loss: 209.2207 - val_loss: 274.403
Epoch 41/5000
1103/1103 [==============================] - 0s 416us/step - loss: 205.0323 - val_loss: 285.703
Epoch 42/5000
1103/1103 [==============================] - 0s 417us/step - loss: 200.7866 - val_loss: 296.687
Epoch 43/5000
1103/1103 [==============================] - 0s 415us/step - loss: 199.0408 - val_loss: 279.573
Epoch 44/5000
1103/1103 [==============================] - 0s 415us/step - loss: 195.8986 - val_loss: 292.575
Epoch 45/5000
1103/1103 [==============================] - 0s 415us/step - loss: 193.6497 - val_loss: 297.731
Epoch 46/5000
1103/1103 [==============================] - 0s 417us/step - loss: 195.0980 - val_loss: 275.695
Epoch 47/5000
1103/1103 [==============================] - 0s 416us/step - loss: 194.6053 - val_loss: 283.068
Epoch 48/5000
1103/1103 [==============================] - 0s 415us/step - loss: 186.3277 - val_loss: 265.214
Epoch 49/5000
1103/1103 [==============================] - 0s 416us/step - loss: 185.8672 - val_loss: 309.653
Epoch 50/5000
```

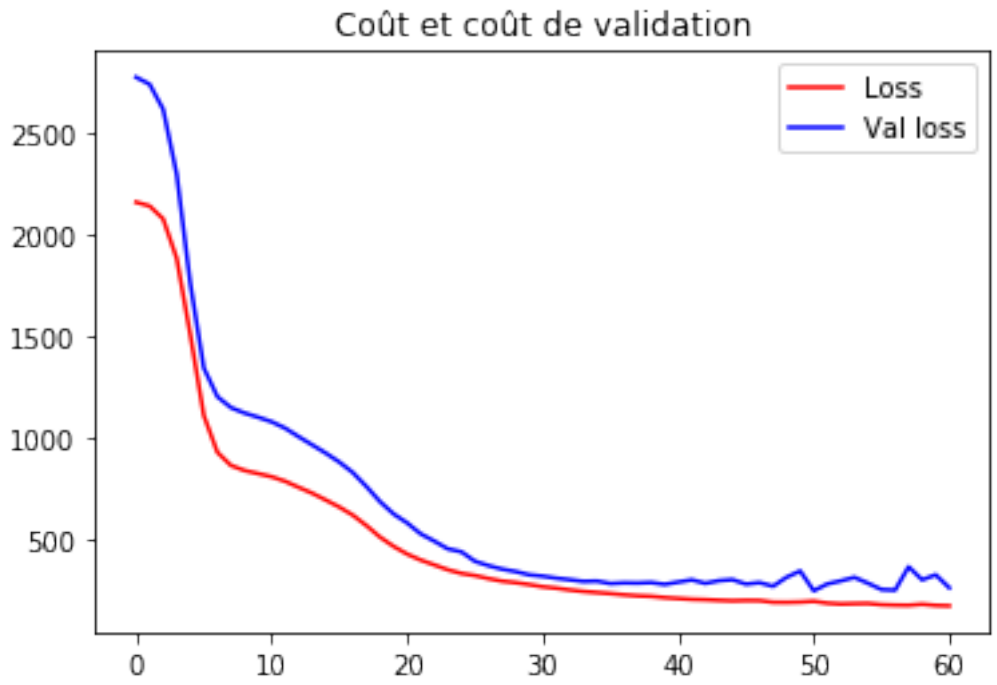
```
1103/1103 [==============================] - 0s 417us/step - loss: 187.3264 - val_loss: 340.476
Epoch 51/5000
1103/1103 [==============================] - 0s 417us/step - loss: 191.2286 - val_loss: 242.882
Epoch 52/5000
1103/1103 [==============================] - 0s 420us/step - loss: 181.7643 - val_loss: 276.479
Epoch 53/5000
1103/1103 [==============================] - 0s 421us/step - loss: 177.8643 - val_loss: 291.602
Epoch 54/5000
1103/1103 [==============================] - 0s 414us/step - loss: 179.4497 - val_loss: 309.039
Epoch 55/5000
1103/1103 [==============================] - 0s 413us/step - loss: 180.3756 - val_loss: 280.104
Epoch 56/5000
1103/1103 [==============================] - 0s 415us/step - loss: 174.2326 - val_loss: 248.941
Epoch 57/5000
1103/1103 [==============================] - 0s 418us/step - loss: 172.1858 - val_loss: 246.091
Epoch 58/5000
1103/1103 [==============================] - 0s 417us/step - loss: 171.3297 - val_loss: 361.203
Epoch 59/5000
1103/1103 [==============================] - 0s 415us/step - loss: 176.4448 - val_loss: 296.953
Epoch 60/5000
1103/1103 [==============================] - 0s 416us/step - loss: 170.5874 - val_loss: 321.577
Epoch 61/5000
1103/1103 [==============================] - 0s 416us/step - loss: 168.6379 - val_loss: 257.747
Epoch 00061: early stopping
```

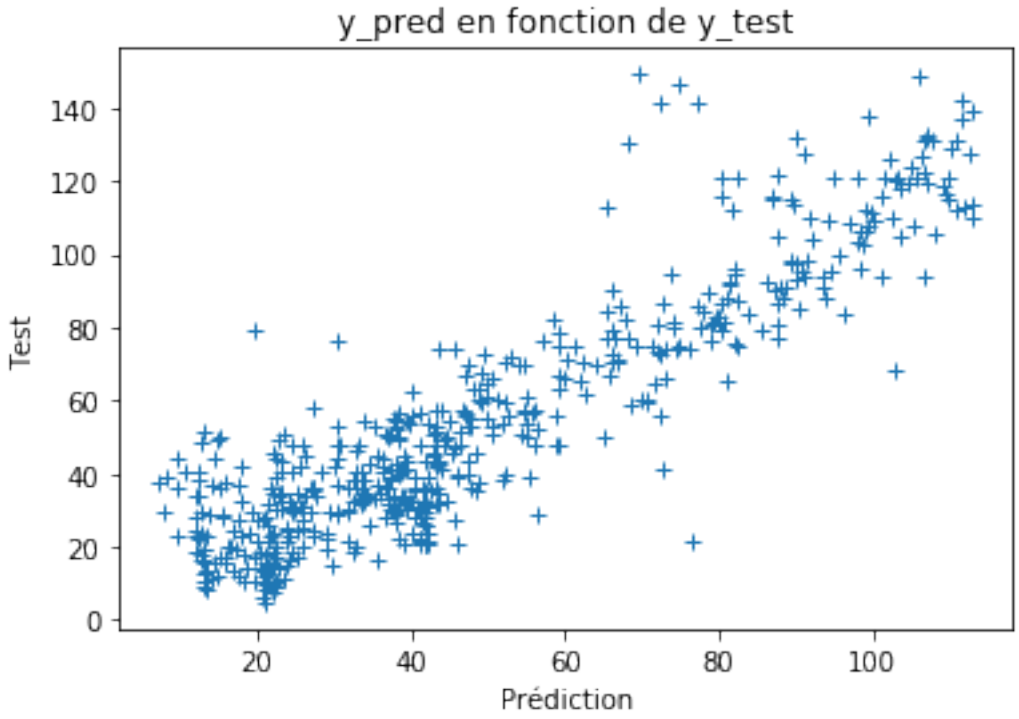
In [12]:
```
y_pred = model.predict(X_test)
plt.title('Coût et coût de validation')
line1,=plt.plot(history.history['loss'], label="Loss", linestyle='-', color='r')
line2,=plt.plot(history.history['val_loss'], label="Val loss", linestyle='-', color='
first_legend = plt.legend(handles=[line1, line2], loc=1)

plt.show()

plt.title('y_pred en fonction de y_test')

plt.plot(y_pred[:], y_test[:], '+')
plt.ylabel('Test')
plt.xlabel('Prédiction')
plt.show()
```






```
In [13]: model = gru_model(32, X_train.shape[1:])
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gru_1 (GRU)                  (None, 32)                3936
_________________________________________________________________
dense_5 (Dense)              (None, 32)                1056
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 33
=================================================================
Total params: 5,025
Trainable params: 5,025
Non-trainable params: 0
_________________________________________________________________
```

```
In [14]: early_stopping = EarlyStopping(monitor='val_loss', verbose=1, mode='auto', patience=1
         history = model.fit(X_train, y_train, batch_size=32, epochs=5000, validation_data=(X_
```

```
Train on 1103 samples, validate on 539 samples
Epoch 1/5000
1103/1103 [==============================] - 1s 1ms/step - loss: 2157.5395 - val_loss: 2771.67
Epoch 2/5000
1103/1103 [==============================] - 0s 357us/step - loss: 2137.5855 - val_loss: 2743.
Epoch 3/5000
1103/1103 [==============================] - 0s 357us/step - loss: 2089.4976 - val_loss: 2656.
Epoch 4/5000
1103/1103 [==============================] - 0s 367us/step - loss: 1926.0092 - val_loss: 2349.
Epoch 5/5000
1103/1103 [==============================] - 0s 357us/step - loss: 1623.7299 - val_loss: 1871.
Epoch 6/5000
1103/1103 [==============================] - 0s 355us/step - loss: 1250.6148 - val_loss: 1440.
Epoch 7/5000
1103/1103 [==============================] - 0s 362us/step - loss: 983.8517 - val_loss: 1200.9
Epoch 8/5000
1103/1103 [==============================] - 0s 373us/step - loss: 840.7496 - val_loss: 1105.9
Epoch 9/5000
1103/1103 [==============================] - 0s 363us/step - loss: 728.7868 - val_loss: 1039.2
Epoch 10/5000
1103/1103 [==============================] - 0s 369us/step - loss: 675.6496 - val_loss: 960.68
Epoch 11/5000
1103/1103 [==============================] - 0s 362us/step - loss: 616.9889 - val_loss: 912.46
Epoch 12/5000
1103/1103 [==============================] - 0s 352us/step - loss: 567.9390 - val_loss: 866.59
Epoch 13/5000
1103/1103 [==============================] - 0s 371us/step - loss: 530.8085 - val_loss: 809.89
Epoch 14/5000
1103/1103 [==============================] - 0s 367us/step - loss: 498.5334 - val_loss: 748.44
Epoch 15/5000
```

```
1103/1103 [==============================] - 0s 359us/step - loss: 466.6451 - val_loss: 686.012
Epoch 16/5000
1103/1103 [==============================] - 0s 365us/step - loss: 435.7949 - val_loss: 618.953
Epoch 17/5000
1103/1103 [==============================] - 0s 352us/step - loss: 404.7453 - val_loss: 564.777
Epoch 18/5000
1103/1103 [==============================] - 0s 363us/step - loss: 376.9718 - val_loss: 506.980
Epoch 19/5000
1103/1103 [==============================] - 0s 352us/step - loss: 352.5374 - val_loss: 473.154
Epoch 20/5000
1103/1103 [==============================] - 0s 356us/step - loss: 330.4900 - val_loss: 431.044
Epoch 21/5000
1103/1103 [==============================] - 0s 361us/step - loss: 311.2408 - val_loss: 406.215
Epoch 22/5000
1103/1103 [==============================] - 0s 356us/step - loss: 294.8164 - val_loss: 380.444
Epoch 23/5000
1103/1103 [==============================] - 0s 362us/step - loss: 282.0599 - val_loss: 359.756
Epoch 24/5000
1103/1103 [==============================] - 0s 353us/step - loss: 271.0121 - val_loss: 346.040
Epoch 25/5000
1103/1103 [==============================] - 0s 375us/step - loss: 262.3890 - val_loss: 330.798
Epoch 26/5000
1103/1103 [==============================] - 0s 375us/step - loss: 254.7172 - val_loss: 321.961
Epoch 27/5000
1103/1103 [==============================] - 0s 365us/step - loss: 248.1485 - val_loss: 318.995
Epoch 28/5000
1103/1103 [==============================] - 0s 360us/step - loss: 242.6345 - val_loss: 310.904
Epoch 29/5000
1103/1103 [==============================] - 0s 376us/step - loss: 237.2965 - val_loss: 302.814
Epoch 30/5000
1103/1103 [==============================] - 0s 375us/step - loss: 232.1358 - val_loss: 298.490
Epoch 31/5000
1103/1103 [==============================] - 0s 355us/step - loss: 227.6713 - val_loss: 299.435
Epoch 32/5000
1103/1103 [==============================] - 0s 367us/step - loss: 223.9714 - val_loss: 297.192
Epoch 33/5000
1103/1103 [==============================] - 0s 369us/step - loss: 220.3724 - val_loss: 290.087
Epoch 34/5000
1103/1103 [==============================] - 0s 355us/step - loss: 216.3683 - val_loss: 284.631
Epoch 35/5000
1103/1103 [==============================] - 0s 358us/step - loss: 212.9724 - val_loss: 286.349
Epoch 36/5000
1103/1103 [==============================] - 0s 351us/step - loss: 210.5322 - val_loss: 293.576
Epoch 37/5000
1103/1103 [==============================] - 0s 351us/step - loss: 208.7492 - val_loss: 288.574
Epoch 38/5000
1103/1103 [==============================] - 0s 351us/step - loss: 206.2481 - val_loss: 277.911
Epoch 39/5000
```

```
1103/1103 [==============================] - 0s 385us/step - loss: 202.5960 - val_loss: 268.755
Epoch 40/5000
1103/1103 [==============================] - 0s 375us/step - loss: 200.5353 - val_loss: 274.399
Epoch 41/5000
1103/1103 [==============================] - 0s 372us/step - loss: 200.0451 - val_loss: 314.043
Epoch 42/5000
1103/1103 [==============================] - 0s 380us/step - loss: 202.1756 - val_loss: 282.987
Epoch 43/5000
1103/1103 [==============================] - 0s 378us/step - loss: 195.9692 - val_loss: 269.359
Epoch 44/5000
1103/1103 [==============================] - 0s 366us/step - loss: 192.2467 - val_loss: 261.830
Epoch 45/5000
1103/1103 [==============================] - 0s 367us/step - loss: 190.2133 - val_loss: 268.250
Epoch 46/5000
1103/1103 [==============================] - 0s 381us/step - loss: 190.8489 - val_loss: 311.517
Epoch 47/5000
1103/1103 [==============================] - 0s 369us/step - loss: 194.0992 - val_loss: 292.449
Epoch 48/5000
1103/1103 [==============================] - 0s 353us/step - loss: 189.4681 - val_loss: 270.183
Epoch 49/5000
1103/1103 [==============================] - 0s 357us/step - loss: 187.2028 - val_loss: 256.244
Epoch 50/5000
1103/1103 [==============================] - 0s 355us/step - loss: 184.0813 - val_loss: 255.153
Epoch 51/5000
1103/1103 [==============================] - 0s 386us/step - loss: 187.5357 - val_loss: 325.778
Epoch 52/5000
1103/1103 [==============================] - 0s 395us/step - loss: 194.1718 - val_loss: 330.542
Epoch 53/5000
1103/1103 [==============================] - 0s 378us/step - loss: 193.4339 - val_loss: 249.986
Epoch 54/5000
1103/1103 [==============================] - 0s 358us/step - loss: 183.3604 - val_loss: 253.593
Epoch 55/5000
1103/1103 [==============================] - 0s 355us/step - loss: 181.4651 - val_loss: 311.924
Epoch 56/5000
1103/1103 [==============================] - 0s 358us/step - loss: 186.7652 - val_loss: 292.508
Epoch 57/5000
1103/1103 [==============================] - 0s 366us/step - loss: 181.4319 - val_loss: 257.790
Epoch 58/5000
1103/1103 [==============================] - 0s 369us/step - loss: 176.0689 - val_loss: 256.596
Epoch 59/5000
1103/1103 [==============================] - 0s 370us/step - loss: 174.0455 - val_loss: 283.339
Epoch 60/5000
1103/1103 [==============================] - 0s 369us/step - loss: 176.2255 - val_loss: 291.327
Epoch 61/5000
1103/1103 [==============================] - 0s 359us/step - loss: 174.9713 - val_loss: 267.161
Epoch 62/5000
1103/1103 [==============================] - 0s 359us/step - loss: 172.4715 - val_loss: 255.288
Epoch 63/5000
```

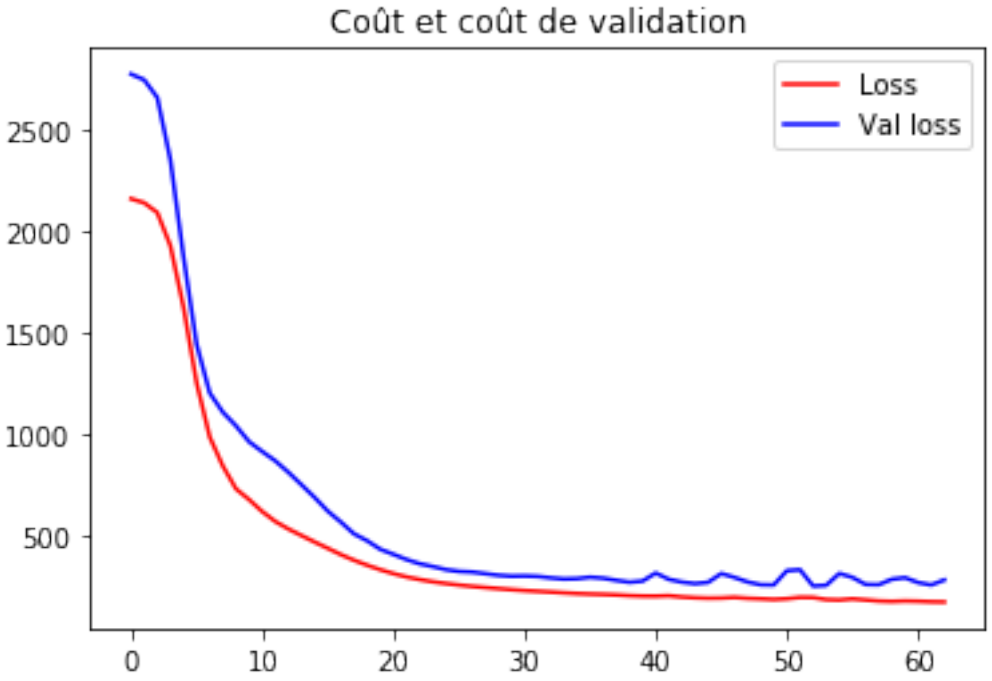
```
1103/1103 [==============================] - 0s 376us/step - loss: 171.4618 - val_loss: 279.874
Epoch 00063: early stopping
```

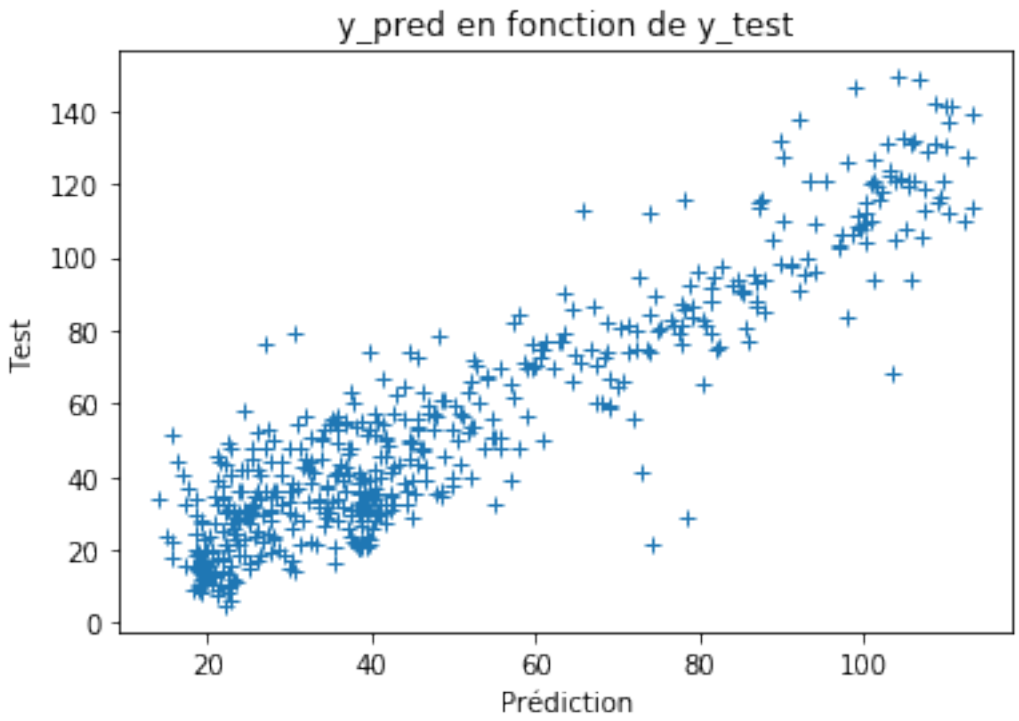
```
In [15]: y_pred = model.predict(X_test)
         plt.title('Coût et coût de validation')
         line1,=plt.plot(history.history['loss'], label="Loss", linestyle='-', color='r')
         line2,=plt.plot(history.history['val_loss'], label="Val loss", linestyle='-', color='
         first_legend = plt.legend(handles=[line1, line2], loc=1)

         plt.show()

         plt.title('y_pred en fonction de y_test')

         plt.plot(y_pred[:], y_test[:], '+')
         plt.ylabel('Test')
         plt.xlabel('Prédiction')
         plt.show()
```




y_pred en fonction de y_test
Test
Prédiction
0
20
40
60
80
100
120
140
20
40
60
80
100

In [ ]: