deep_learning

January 15, 2023

0.1 Importation of librairies

[44]:
```
import pandas as pd
import numpy as np
import keras
from keras.models import Sequential
from keras.layers import Dense
import sklearn
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import StandardScaler
```

0.2 Data

[45]:
```
concrete_data = pd.read_csv('https://s3-api.us-geo.objectstorage.softlayer.net/
↪cf-courses-data/CognitiveClass/DL0101EN/labs/data/concrete_data.csv')
concrete_data.head()
```

[45]:

	Cement	Blast Furnace Slag	Fly Ash	Water	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age	Strength
0	540.0	0.0	0.0	162.0	2.5	1040.0	676.0	28	79.99
1	540.0	0.0	0.0	162.0	2.5	1055.0	676.0	28	61.89
2	332.5	142.5	0.0	228.0	0.0	932.0	594.0	270	40.27
3	332.5	142.5	0.0	228.0	0.0	932.0	594.0	365	41.05
4	198.6	132.4	0.0	192.0	0.0	978.4	825.5	360	44.30

0.3 Dimensions

[46]:
```
concrete_data.shape
```

[46]: (1030, 9)

[47]:
```
concrete_data.describe()
```

[47]:

	Cement	Blast Furnace Slag	Fly Ash	Water
count	1030.000000	1030.000000	1030.000000	1030.000000
mean	281.167864	73.895825	54.188350	181.567282
std	104.506364	86.279342	63.997004	21.354219
min	102.000000	0.000000	0.000000	121.800000
25%	192.375000	0.000000	0.000000	164.900000
50%	272.900000	22.000000	0.000000	185.000000
75%	350.000000	142.950000	118.300000	192.000000
max	540.000000	359.400000	200.100000	247.000000

	Superplasticizer	Coarse Aggregate	Fine Aggregate	Age
count	1030.000000	1030.000000	1030.000000	1030.000000
mean	6.204660	972.918932	773.580485	45.662136
std	5.973841	77.753954	80.175980	63.169912
min	0.000000	801.000000	594.000000	1.000000
25%	0.000000	932.000000	730.950000	7.000000
50%	6.400000	968.000000	779.500000	28.000000
75%	10.200000	1029.400000	824.000000	56.000000
max	32.200000	1145.000000	992.600000	365.000000

	Strength
count	1030.000000
mean	35.817961
std	16.705742
min	2.330000
25%	23.710000
50%	34.445000
75%	46.135000
max	82.600000

0.4 Definition of predictor and label

[48]:
```
concrete_data_columns = concrete_data.columns

predictors = concrete_data[concrete_data_columns[concrete_data_columns !=␣
  ↪'Strength']] # all columns except Strength
target = concrete_data['Strength'] # Strength column
```

[49]:
```
# Consulatation de target
target.head()
```

[49]:
```
0    79.99
1    61.89
2    40.27
3    41.05
```

```
4    44.30
Name: Strength, dtype: float64
```

[50]:
```
# Consultation of predictor
predictors.head()
```

[50]:
```
   Cement  Blast Furnace Slag  Fly Ash  Water  Superplasticizer  \
0   540.0                 0.0      0.0  162.0               2.5
1   540.0                 0.0      0.0  162.0               2.5
2   332.5               142.5      0.0  228.0               0.0
3   332.5               142.5      0.0  228.0               0.0
4   198.6               132.4      0.0  192.0               0.0

   Coarse Aggregate  Fine Aggregate  Age
0            1040.0           676.0   28
1            1055.0           676.0   28
2             932.0           594.0  270
3             932.0           594.0  365
4             978.4           825.5  360
```

[51]:
```
scaler = StandardScaler()
predictors = scaler.fit_transform(predictors)
```

```
/home/jupyterlab/conda/envs/python/lib/python3.7/site-
packages/sklearn/preprocessing/data.py:625: DataConversionWarning: Data with
input dtype int64, float64 were all converted to float64 by StandardScaler.
  return self.partial_fit(X, y)
/home/jupyterlab/conda/envs/python/lib/python3.7/site-
packages/sklearn/base.py:462: DataConversionWarning: Data with input dtype
int64, float64 were all converted to float64 by StandardScaler.
  return self.fit(X, **fit_params).transform(X)
```

0.5 Devision of Data Set

[52]:
```
x_train, x_test, y_train, y_test = train_test_split(
...     predictors, target, test_size=0.3, random_state=4
... )
```

[53]:
```
# Analyse of shape
x_test.shape
```

[53]:
```
(309, 8)
```

[54]:
```
x_train.shape
```

[54]:
```
(721, 8)
```

0.6 Model

[55]:
```
# define regression model
def regression_model():
    # create model
    model = Sequential()
    model.add(Dense(50, activation='relu', input_shape=(8,)))
    model.add(Dense(10, activation='relu'))
    model.add(Dense(1))

    # compile model
    model.compile(optimizer='adam', loss='mean_squared_error')
    return model
```

[56]:
```
# build the model
model = regression_model()
```

[60]:
```
# fit the model
model.fit(predictors, target, epochs=100)
```

```
Epoch 1/100
1030/1030 [==============================] - 0s 102us/step - loss: 50.6955
Epoch 2/100
1030/1030 [==============================] - 0s 104us/step - loss: 47.9867
Epoch 3/100
1030/1030 [==============================] - 0s 99us/step - loss: 46.2385
Epoch 4/100
1030/1030 [==============================] - 0s 99us/step - loss: 45.2636
Epoch 5/100
1030/1030 [==============================] - 0s 110us/step - loss: 44.8517
Epoch 6/100
1030/1030 [==============================] - 0s 100us/step - loss: 43.9128
Epoch 7/100
1030/1030 [==============================] - 0s 102us/step - loss: 43.3385
Epoch 8/100
1030/1030 [==============================] - 0s 114us/step - loss: 42.4262
Epoch 9/100
1030/1030 [==============================] - 0s 108us/step - loss: 42.1119
Epoch 10/100
1030/1030 [==============================] - 0s 98us/step - loss: 41.3634
Epoch 11/100
1030/1030 [==============================] - 0s 102us/step - loss: 41.0319
Epoch 12/100
1030/1030 [==============================] - 0s 108us/step - loss: 40.5924
Epoch 13/100
1030/1030 [==============================] - 0s 100us/step - loss: 40.2281
Epoch 14/100
1030/1030 [==============================] - 0s 100us/step - loss: 39.8641
```

```
Epoch 15/100
1030/1030 [==============================] - 0s 97us/step - loss: 39.4579
Epoch 16/100
1030/1030 [==============================] - 0s 107us/step - loss: 39.0111
Epoch 17/100
1030/1030 [==============================] - 0s 99us/step - loss: 38.6803
Epoch 18/100
1030/1030 [==============================] - 0s 99us/step - loss: 38.4484
Epoch 19/100
1030/1030 [==============================] - 0s 98us/step - loss: 38.0682
Epoch 20/100
1030/1030 [==============================] - 0s 101us/step - loss: 38.3588
Epoch 21/100
1030/1030 [==============================] - 0s 110us/step - loss: 37.5126
Epoch 22/100
1030/1030 [==============================] - 0s 101us/step - loss: 37.3563
Epoch 23/100
1030/1030 [==============================] - 0s 132us/step - loss: 37.1131
Epoch 24/100
1030/1030 [==============================] - 0s 100us/step - loss: 36.9340
Epoch 25/100
1030/1030 [==============================] - 0s 111us/step - loss: 36.7858
Epoch 26/100
1030/1030 [==============================] - 0s 102us/step - loss: 36.5800
Epoch 27/100
1030/1030 [==============================] - 0s 97us/step - loss: 36.4024
Epoch 28/100
1030/1030 [==============================] - 0s 108us/step - loss: 36.2644
Epoch 29/100
1030/1030 [==============================] - 0s 101us/step - loss: 35.7509
Epoch 30/100
1030/1030 [==============================] - 0s 114us/step - loss: 35.7774
Epoch 31/100
1030/1030 [==============================] - 0s 99us/step - loss: 35.4841
Epoch 32/100
1030/1030 [==============================] - 0s 97us/step - loss: 35.3547
Epoch 33/100
1030/1030 [==============================] - 0s 94us/step - loss: 35.1821
Epoch 34/100
1030/1030 [==============================] - 0s 110us/step - loss: 34.8573
Epoch 35/100
1030/1030 [==============================] - 0s 97us/step - loss: 34.7565
Epoch 36/100
1030/1030 [==============================] - 0s 98us/step - loss: 34.3739
Epoch 37/100
1030/1030 [==============================] - 0s 98us/step - loss: 34.2862
Epoch 38/100
1030/1030 [==============================] - 0s 97us/step - loss: 34.4596
```

```
Epoch 39/100
1030/1030 [==============================] - 0s 108us/step - loss: 33.9409
Epoch 40/100
1030/1030 [==============================] - 0s 85us/step - loss: 33.7924
Epoch 41/100
1030/1030 [==============================] - 0s 103us/step - loss: 33.5202
Epoch 42/100
1030/1030 [==============================] - 0s 96us/step - loss: 33.4796
Epoch 43/100
1030/1030 [==============================] - 0s 100us/step - loss: 33.3823
Epoch 44/100
1030/1030 [==============================] - 0s 101us/step - loss: 33.1665
Epoch 45/100
1030/1030 [==============================] - 0s 112us/step - loss: 33.5561
Epoch 46/100
1030/1030 [==============================] - 0s 96us/step - loss: 33.0574
Epoch 47/100
1030/1030 [==============================] - 0s 99us/step - loss: 32.7136
Epoch 48/100
1030/1030 [==============================] - 0s 99us/step - loss: 32.8439
Epoch 49/100
1030/1030 [==============================] - 0s 110us/step - loss: 32.7507
Epoch 50/100
1030/1030 [==============================] - 0s 99us/step - loss: 32.5728
Epoch 51/100
1030/1030 [==============================] - 0s 95us/step - loss: 32.1586
Epoch 52/100
1030/1030 [==============================] - 0s 99us/step - loss: 32.0846
Epoch 53/100
1030/1030 [==============================] - 0s 99us/step - loss: 32.3320
Epoch 54/100
1030/1030 [==============================] - 0s 109us/step - loss: 31.7829
Epoch 55/100
1030/1030 [==============================] - 0s 101us/step - loss: 31.6327
Epoch 56/100
1030/1030 [==============================] - 0s 96us/step - loss: 31.7604
Epoch 57/100
1030/1030 [==============================] - 0s 98us/step - loss: 31.6185
Epoch 58/100
1030/1030 [==============================] - 0s 98us/step - loss: 31.2964
Epoch 59/100
1030/1030 [==============================] - 0s 99us/step - loss: 31.2093
Epoch 60/100
1030/1030 [==============================] - 0s 115us/step - loss: 31.4745
Epoch 61/100
1030/1030 [==============================] - 0s 99us/step - loss: 31.5248
Epoch 62/100
1030/1030 [==============================] - 0s 109us/step - loss: 31.0413
```

```
Epoch 63/100
1030/1030 [==============================] - 0s 96us/step - loss: 31.1982
Epoch 64/100
1030/1030 [==============================] - 0s 116us/step - loss: 30.7339
Epoch 65/100
1030/1030 [==============================] - 0s 99us/step - loss: 30.5180
Epoch 66/100
1030/1030 [==============================] - 0s 98us/step - loss: 30.4225
Epoch 67/100
1030/1030 [==============================] - 0s 110us/step - loss: 30.2446
Epoch 68/100
1030/1030 [==============================] - 0s 96us/step - loss: 30.4679
Epoch 69/100
1030/1030 [==============================] - 0s 97us/step - loss: 31.1176
Epoch 70/100
1030/1030 [==============================] - 0s 99us/step - loss: 30.6629
Epoch 71/100
1030/1030 [==============================] - 0s 97us/step - loss: 30.3001
Epoch 72/100
1030/1030 [==============================] - 0s 95us/step - loss: 29.8359
Epoch 73/100
1030/1030 [==============================] - 0s 115us/step - loss: 29.9571
Epoch 74/100
1030/1030 [==============================] - 0s 99us/step - loss: 29.6772
Epoch 75/100
1030/1030 [==============================] - 0s 96us/step - loss: 30.0241
Epoch 76/100
1030/1030 [==============================] - 0s 98us/step - loss: 29.7291
Epoch 77/100
1030/1030 [==============================] - 0s 98us/step - loss: 29.8370
Epoch 78/100
1030/1030 [==============================] - 0s 98us/step - loss: 29.2822
Epoch 79/100
1030/1030 [==============================] - 0s 96us/step - loss: 29.2600
Epoch 80/100
1030/1030 [==============================] - 0s 98us/step - loss: 29.2024
Epoch 81/100
1030/1030 [==============================] - 0s 133us/step - loss: 28.9867
Epoch 82/100
1030/1030 [==============================] - 0s 99us/step - loss: 28.9744
Epoch 83/100
1030/1030 [==============================] - 0s 112us/step - loss: 28.7855
Epoch 84/100
1030/1030 [==============================] - 0s 98us/step - loss: 28.7135
Epoch 85/100
1030/1030 [==============================] - 0s 99us/step - loss: 28.4656
Epoch 86/100
1030/1030 [==============================] - 0s 113us/step - loss: 28.2818
```

```
Epoch 87/100
1030/1030 [==============================] - 0s 98us/step - loss: 28.2969
Epoch 88/100
1030/1030 [==============================] - 0s 111us/step - loss: 28.0584
Epoch 89/100
1030/1030 [==============================] - 0s 101us/step - loss: 28.9096
Epoch 90/100
1030/1030 [==============================] - 0s 115us/step - loss: 28.1340
Epoch 91/100
1030/1030 [==============================] - 0s 96us/step - loss: 28.2805
Epoch 92/100
1030/1030 [==============================] - 0s 113us/step - loss: 28.0442
Epoch 93/100
1030/1030 [==============================] - 0s 97us/step - loss: 27.7925
Epoch 94/100
1030/1030 [==============================] - 0s 98us/step - loss: 27.7574
Epoch 95/100
1030/1030 [==============================] - 0s 97us/step - loss: 27.9679
Epoch 96/100
1030/1030 [==============================] - 0s 109us/step - loss: 27.7138
Epoch 97/100
1030/1030 [==============================] - 0s 101us/step - loss: 27.4180
Epoch 98/100
1030/1030 [==============================] - 0s 95us/step - loss: 27.3970
Epoch 99/100
1030/1030 [==============================] - 0s 98us/step - loss: 27.1697
Epoch 100/100
1030/1030 [==============================] - 0s 98us/step - loss: 27.2069
```

[60]: `<keras.callbacks.History at 0x7ff24c57d550>`

0.7 Evaluation

[61]:
```
y_predic = model.predict(x_test)
mean_squared_error(y_test, y_predic)
```

[61]: `26.816456942347063`

0.8 Repeatition

[62]:
```
# fit the model
model.fit(predictors, target, validation_split=0.3, epochs=100, verbose=2)
```

```
Train on 721 samples, validate on 309 samples
Epoch 1/100
 - 0s - loss: 27.6514 - val_loss: 26.7181
Epoch 2/100
```

```
 - 0s - loss: 27.2272 - val_loss: 27.1457
Epoch 3/100
 - 0s - loss: 26.9068 - val_loss: 27.9429
Epoch 4/100
 - 0s - loss: 26.5754 - val_loss: 31.0706
Epoch 5/100
 - 0s - loss: 26.4107 - val_loss: 30.2738
Epoch 6/100
 - 0s - loss: 26.4312 - val_loss: 30.9707
Epoch 7/100
 - 0s - loss: 26.1388 - val_loss: 33.8436
Epoch 8/100
 - 0s - loss: 25.9234 - val_loss: 34.1390
Epoch 9/100
 - 0s - loss: 25.8218 - val_loss: 35.6329
Epoch 10/100
 - 0s - loss: 26.0420 - val_loss: 33.9028
Epoch 11/100
 - 0s - loss: 25.6425 - val_loss: 38.5717
Epoch 12/100
 - 0s - loss: 25.3133 - val_loss: 37.4300
Epoch 13/100
 - 0s - loss: 25.3510 - val_loss: 37.5939
Epoch 14/100
 - 0s - loss: 25.1461 - val_loss: 36.3547
Epoch 15/100
 - 0s - loss: 24.8082 - val_loss: 39.1469
Epoch 16/100
 - 0s - loss: 25.0193 - val_loss: 39.4405
Epoch 17/100
 - 0s - loss: 24.6984 - val_loss: 40.9481
Epoch 18/100
 - 0s - loss: 24.5285 - val_loss: 42.1599
Epoch 19/100
 - 0s - loss: 24.4932 - val_loss: 42.2584
Epoch 20/100
 - 0s - loss: 24.5880 - val_loss: 45.7306
Epoch 21/100
 - 0s - loss: 24.7224 - val_loss: 40.1953
Epoch 22/100
 - 0s - loss: 24.0138 - val_loss: 46.6536
Epoch 23/100
 - 0s - loss: 24.2600 - val_loss: 42.7184
Epoch 24/100
 - 0s - loss: 23.7404 - val_loss: 42.8409
Epoch 25/100
 - 0s - loss: 23.9400 - val_loss: 42.7951
Epoch 26/100
```

```
 - 0s - loss: 23.7942 - val_loss: 45.2678
Epoch 27/100
 - 0s - loss: 23.7187 - val_loss: 45.8173
Epoch 28/100
 - 0s - loss: 23.5183 - val_loss: 46.6355
Epoch 29/100
 - 0s - loss: 23.5583 - val_loss: 47.9172
Epoch 30/100
 - 0s - loss: 23.2828 - val_loss: 45.0000
Epoch 31/100
 - 0s - loss: 23.4856 - val_loss: 47.4017
Epoch 32/100
 - 0s - loss: 23.1342 - val_loss: 43.9824
Epoch 33/100
 - 0s - loss: 23.0986 - val_loss: 48.2224
Epoch 34/100
 - 0s - loss: 23.0709 - val_loss: 45.9992
Epoch 35/100
 - 0s - loss: 23.0320 - val_loss: 47.7009
Epoch 36/100
 - 0s - loss: 22.7366 - val_loss: 50.0946
Epoch 37/100
 - 0s - loss: 22.8578 - val_loss: 47.2311
Epoch 38/100
 - 0s - loss: 22.7959 - val_loss: 47.1853
Epoch 39/100
 - 0s - loss: 22.5749 - val_loss: 48.3882
Epoch 40/100
 - 0s - loss: 22.4292 - val_loss: 49.2524
Epoch 41/100
 - 0s - loss: 22.6092 - val_loss: 46.3909
Epoch 42/100
 - 0s - loss: 22.6339 - val_loss: 50.6124
Epoch 43/100
 - 0s - loss: 22.5276 - val_loss: 52.7955
Epoch 44/100
 - 0s - loss: 22.3218 - val_loss: 50.6600
Epoch 45/100
 - 0s - loss: 22.1902 - val_loss: 48.4503
Epoch 46/100
 - 0s - loss: 22.5050 - val_loss: 49.5840
Epoch 47/100
 - 0s - loss: 22.0278 - val_loss: 50.9554
Epoch 48/100
 - 0s - loss: 22.1431 - val_loss: 51.0026
Epoch 49/100
 - 0s - loss: 21.7750 - val_loss: 51.0371
Epoch 50/100
```

```
 - 0s - loss: 21.7520 - val_loss: 51.4368
Epoch 51/100
 - 0s - loss: 21.7514 - val_loss: 51.8920
Epoch 52/100
 - 0s - loss: 21.6032 - val_loss: 52.1241
Epoch 53/100
 - 0s - loss: 21.7994 - val_loss: 55.3156
Epoch 54/100
 - 0s - loss: 21.7846 - val_loss: 56.2770
Epoch 55/100
 - 0s - loss: 21.7279 - val_loss: 50.5802
Epoch 56/100
 - 0s - loss: 21.7673 - val_loss: 52.4250
Epoch 57/100
 - 0s - loss: 22.0499 - val_loss: 54.5321
Epoch 58/100
 - 0s - loss: 21.5359 - val_loss: 54.0520
Epoch 59/100
 - 0s - loss: 21.2320 - val_loss: 51.4183
Epoch 60/100
 - 0s - loss: 21.6505 - val_loss: 57.2122
Epoch 61/100
 - 0s - loss: 21.1462 - val_loss: 50.6047
Epoch 62/100
 - 0s - loss: 21.0184 - val_loss: 54.1259
Epoch 63/100
 - 0s - loss: 21.1266 - val_loss: 54.0818
Epoch 64/100
 - 0s - loss: 21.0694 - val_loss: 56.2708
Epoch 65/100
 - 0s - loss: 20.9245 - val_loss: 53.5607
Epoch 66/100
 - 0s - loss: 20.9734 - val_loss: 57.1134
Epoch 67/100
 - 0s - loss: 20.7338 - val_loss: 55.8516
Epoch 68/100
 - 0s - loss: 20.8957 - val_loss: 56.9032
Epoch 69/100
 - 0s - loss: 20.4596 - val_loss: 56.4812
Epoch 70/100
 - 0s - loss: 20.5310 - val_loss: 54.5214
Epoch 71/100
 - 0s - loss: 20.7252 - val_loss: 57.3305
Epoch 72/100
 - 0s - loss: 20.5614 - val_loss: 59.2334
Epoch 73/100
 - 0s - loss: 20.6817 - val_loss: 55.8274
Epoch 74/100
```

```
 - 0s - loss: 20.5470 - val_loss: 57.0614
Epoch 75/100
 - 0s - loss: 20.2023 - val_loss: 56.3856
Epoch 76/100
 - 0s - loss: 20.1201 - val_loss: 57.6644
Epoch 77/100
 - 0s - loss: 20.1327 - val_loss: 58.5053
Epoch 78/100
 - 0s - loss: 20.2491 - val_loss: 59.4613
Epoch 79/100
 - 0s - loss: 20.0142 - val_loss: 56.4764
Epoch 80/100
 - 0s - loss: 20.2798 - val_loss: 56.0911
Epoch 81/100
 - 0s - loss: 20.0488 - val_loss: 58.0861
Epoch 82/100
 - 0s - loss: 20.1236 - val_loss: 54.6698
Epoch 83/100
 - 0s - loss: 19.9860 - val_loss: 57.9420
Epoch 84/100
 - 0s - loss: 19.8933 - val_loss: 58.6152
Epoch 85/100
 - 0s - loss: 20.0914 - val_loss: 56.0940
Epoch 86/100
 - 0s - loss: 19.7846 - val_loss: 60.0922
Epoch 87/100
 - 0s - loss: 19.5512 - val_loss: 57.4976
Epoch 88/100
 - 0s - loss: 19.5782 - val_loss: 60.7373
Epoch 89/100
 - 0s - loss: 19.7394 - val_loss: 59.3491
Epoch 90/100
 - 0s - loss: 19.5419 - val_loss: 60.7010
Epoch 91/100
 - 0s - loss: 19.5782 - val_loss: 58.1925
Epoch 92/100
 - 0s - loss: 19.4319 - val_loss: 59.7472
Epoch 93/100
 - 0s - loss: 19.4887 - val_loss: 60.7649
Epoch 94/100
 - 0s - loss: 19.4016 - val_loss: 60.3446
Epoch 95/100
 - 0s - loss: 19.1562 - val_loss: 60.6186
Epoch 96/100
 - 0s - loss: 19.2310 - val_loss: 62.0954
Epoch 97/100
 - 0s - loss: 19.1585 - val_loss: 62.8128
Epoch 98/100
```

```
 - 0s - loss: 19.1445 - val_loss: 60.9325
Epoch 99/100
 - 0s - loss: 19.3127 - val_loss: 58.8397
Epoch 100/100
 - 0s - loss: 19.2672 - val_loss: 68.2986
```

[62]:
```
<keras.callbacks.History at 0x7ff24c58fa90>
```

[ ]:

[ ]: