2348542_CIA_Component_2

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1 CIA Component 2

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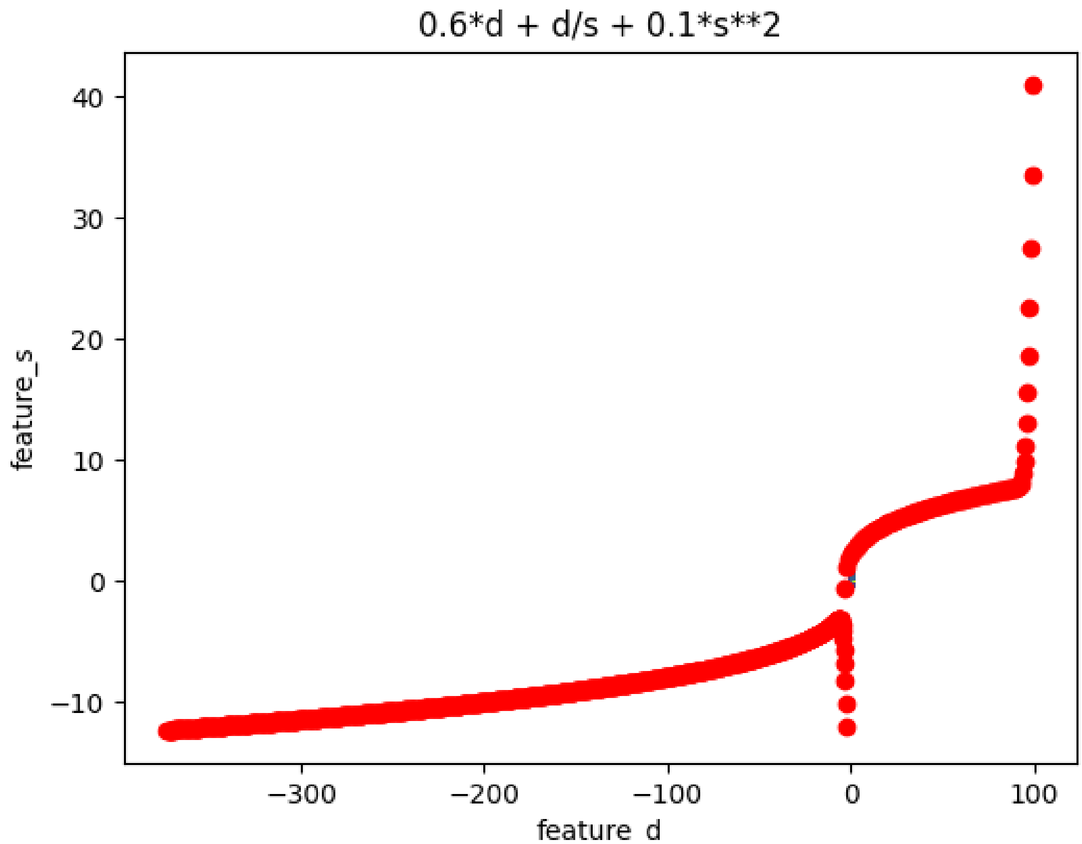
1.0.1 Question 1

[26]:
```
import numpy as np
import sympy as sp
import random
import matplotlib.pyplot as plt

# Creating the symbols
d, s = sp.symbols("d s")

# Creating the function
f_d_s = 0.1*(s**2) + d/s + 0.6*d

# Calculating the gradient of the function
grad_f = sp.lambdify((d, s), sp.derive_by_array(f_d_s, (d, s)))

# Gradient Descent parameters
alpha = 0.01
max_iter = 1000
momentum = 0.9
initial_s, initial_d = 50, 100
starting_point = sp.Matrix([initial_d, initial_s])
prev_grad = sp.Matrix([0,0])

# Values to plot the graph
d_descent, s_descent = [], []

for i in range(max_iter):
    # Computing the gradient at the current point
    grad = sp.Matrix(grad_f(starting_point[0], starting_point[1]))
    # Updating the values of d and s
    starting_point -= (momentum*grad + alpha*prev_grad)
```

```python
    # Keeping track of the starting points for every iteration
    d_descent.append(starting_point[0])
    s_descent.append(starting_point[1])
    # Updating the value of the prev_grad
    prev_grad = grad

    # Checking for convergence
    if grad.norm() < 0.02:
        print(f"Number of iterations taken to converge: {i}")
        minimum_ds = starting_point
        # Evaluate f_d_s at the minimum
        minimum_cost = f_d_s.subs({d:minimum_ds[0], s:minimum_ds[1]})
        print(f"Minimum value of d and s: {minimum_ds}")
        print(f"Minimum cost: {minimum_cost}")
        break
else:
    print("Failed to converge")

# Printing the value after the third iteration
print(f'The values after the thrid iteration were:\ns:{s_descent[2]}\nd:
 ↪{d_descent[2]}')

# Plotting
feature_d = np.linspace(-0.5, 2.0, 70)
feature_s = np.linspace(-0.5, 2.0, 70)

# Creating 2-D grid of features
[D, S] = np.meshgrid(feature_d, feature_s)

fig, ax = plt.subplots(1, 1)

func = 0.1*(S**2) + D/S + 0.6*D

# plots filled contour plot
ax.contourf(D, S, func)
ax.scatter(d_descent, s_descent, c='r')

ax.set_title(f_d_s)
ax.set_xlabel('feature_d')
ax.set_ylabel('feature_s')

plt.show()
```

```
Failed to converge
The values after the thrid iteration were:
s:27.5518410771068
d:98.3008410801840
```



1.0.2 Question 2

1.0.3 Data Preprocessing

[18]:
```python
import pandas as pd
import seaborn as sns

df = pd.read_csv('GME_stock.csv')
df
```

[18]:
```
            date  open_price  high_price   low_price  close_price  \
0     2021-01-28  265.000000  483.000000  112.250000   193.600006
1     2021-01-27  354.829987  380.000000  249.000000   347.510010
2     2021-01-26   88.559998  150.000000   80.199997   147.979996
3     2021-01-25   96.730003  159.179993   61.130001    76.790001
4     2021-01-22   42.590000   76.760002   42.320000    65.010002
…            …          …           …          …           …
4768  2002-02-20    9.600000    9.875000    9.525000     9.875000
4769  2002-02-19    9.900000    9.900000    9.375000     9.550000
4770  2002-02-15   10.000000   10.025000    9.850000     9.950000
```

```
4771  2002-02-14   10.175000   10.195000    9.925000    10.000000
4772  2002-02-13    9.625000   10.060000    9.525000    10.050000

            volume  adjclose_price
0       58815800.0      193.600006
1       93396700.0      347.510010
2      178588000.0      147.979996
3      177874000.0       76.790001
4      196784300.0       65.010002
…              …             …
4768     1723200.0        6.648838
4769     1852600.0        6.430017
4770     2097400.0        6.699336
4771     2755400.0        6.733003
4772    19054000.0        6.766666

[4773 rows x 7 columns]
```

[20]:
```python
# Checking for missing values
df.isna().sum()
```

[20]:
```
date              0
open_price        0
high_price        0
low_price         0
close_price       0
volume            0
adjclose_price    0
dtype: int64
```

There are no missing values and no categorical variables. We will proceed by dropping the `date` feature and scaling the numerical (all) features.

[28]:
```python
df.drop('date', inplace=True, axis=1)
```

[30]:
```python
# Scaling the features
from sklearn.preprocessing import StandardScaler

ss = StandardScaler()
df = pd.DataFrame(ss.fit_transform(df), columns=df.columns)
df
```

[30]:
```
      open_price  high_price  low_price  close_price     volume  \
0      16.455242   28.337343   6.570575    11.742172   8.465412
1      22.568477   21.982661  16.605972    22.347605  13.747883
2       4.447901    7.792593   4.218586     8.598647  26.761441
3       5.003898    8.358962   2.819135     3.693177  26.652373
4       1.319487    3.273982   1.438763     2.881456  29.541052
```

```
…          …          …          …          …          …
4768   -0.925594   -0.852551  -0.967897    -0.917716  -0.255876
4769   -0.905179   -0.851009  -0.978905    -0.940110  -0.236109
4770   -0.898373   -0.843297  -0.944047    -0.912548  -0.198715
4771   -0.886464   -0.832808  -0.938543    -0.909102  -0.098201
4772   -0.923893   -0.841137  -0.967897    -0.905657   2.391523

      adjclose_price
0          16.037784
1          30.005731
2          11.897585
3           5.436809
4           4.367727
…                …
4768       -0.928782
4769       -0.948641
4770       -0.924199
4771       -0.921143
4772       -0.918088

[4773 rows x 6 columns]
```

For anomaly detection, since we have multivariate data, we will use Hotelling's T2 on the multidimensional space of PCA.

[34]:
```python
from pca import pca

# Instantiating PCA
model = pca(normalize=True, detect_outliers=['ht2'], n_std=2)

# Getting the results
results = model.fit_transform(df)
```

```
[pca] >Extracting column labels from dataframe.
[pca] >Extracting row labels from dataframe.
[pca] >Normalizing input data per feature (zero mean and unit variance)..
[pca] >The PCA reduction is performed to capture [95.0%] explained variance
using the [6] columns of the input data.
[pca] >Fit using PCA.
[pca] >Compute loadings and PCs.
[pca] >Compute explained variance.
[pca] >Number of components is [2] that covers the [95.00%] explained variance.
[pca] >The PCA reduction is performed on the [6] columns of the input dataframe.
[pca] >Fit using PCA.
[pca] >Compute loadings and PCs.
[pca] >Outlier detection using Hotelling T2 test with alpha=[0.05] and
n_components=[2]
[pca] >Multiple test correction applied for Hotelling T2 test: [fdr_bh]
```

[37]:
```
# Looking at the p-values of outliers
outliers = results['outliers'][results['outliers']['y_bool']]
outliers
```

[37]:

	y_proba	p_raw	y_score	y_bool
0	2.388153e-298	2.501731e-301	1397.423597	True
1	8.623688e-302	5.420294e-305	1414.321950	True
2	0.000000e+00	0.000000e+00	2763.102112	True
3	0.000000e+00	0.000000e+00	1453.638363	True
4	9.563799e-302	8.014916e-305	1413.538534	True
5	6.487987e-04	1.495241e-06	32.523428	True
7	2.306379e-07	3.865709e-10	49.858141	True
9	2.123054e-12	3.113634e-15	74.083336	True
10	2.585578e-296	3.250255e-299	1387.675776	True
75	6.040898e-07	1.139076e-09	47.608112	True
76	6.386411e-07	1.338029e-09	47.272578	True

[40]:
```
# Removing the outliers
df = df.drop(outliers.index)
df
```

[40]:

	open_price	high_price	low_price	close_price	volume	adjclose_price
6	0.964248	1.079457	0.979373	1.097461	4.593941	2.018106
8	1.040468	1.052311	0.828934	0.848019	6.622614	1.689576
11	-0.220561	-0.203201	-0.249091	-0.223481	0.559464	0.278352
12	-0.257991	-0.187777	-0.271841	-0.224170	1.761187	0.277444
13	-0.341696	-0.332763	-0.413474	-0.379210	0.468390	0.073248
…	…	…	…	…	…	…
4768	-0.925594	-0.852551	-0.967897	-0.917716	-0.255876	-0.928782
4769	-0.905179	-0.851009	-0.978905	-0.940110	-0.236109	-0.948641
4770	-0.898373	-0.843297	-0.944047	-0.912548	-0.198715	-0.924199
4771	-0.886464	-0.832808	-0.938543	-0.909102	-0.098201	-0.921143
4772	-0.923893	-0.841137	-0.967897	-0.905657	2.391523	-0.918088

[4762 rows x 6 columns]

1.0.4 Splitting the dataset

[47]:
```
from sklearn.model_selection import train_test_split

X = df.drop('close_price', axis=1).values
y = df['close_price']

# Splitting the dataset into training and testing set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)

# Splitting the training set into training and validation set
```

```
X_val, X_train, y_val, y_train = train_test_split(X_train, y_train, test_size=0.
 ↪9)

X_train.shape, X_val.shape, X_test.shape
```

[47]: ((3429, 5), (380, 5), (953, 5))

1.0.5 Building the neural network

[55]:
```
import tensorflow as tf
from tensorflow.keras.layers import *

class MyModel(tf.keras.models.Model):

    def __init__(self):
        super().__init__()
        self.dense_1 = Dense(128, activation=tf.nn.relu)
        self.dense_2 = Dense(128, activation=tf.nn.relu)
        self.dense_3 = Dense(128, activation=tf.nn.relu)
        self.dropout_1 = Dropout(0.2)
        self.dropout_2 = Dropout(0.2)
        self.regression = Dense(1)

    def call(self, input_tensor):
        x = self.dense_1(input_tensor)
        x = self.dropout_1(x)
        x = self.dense_2(x)
        x = self.dropout_2(x)
        x = self.dense_3(x)
        return self.regression(x)

model = MyModel()

model.compile(loss=tf.keras.losses.MeanSquaredError(),
              optimizer=tf.keras.optimizers.Adam(),
              metrics=tf.keras.metrics.MeanSquaredError())

history = model.fit(X_train, y_train, epochs=100,
                    validation_data=(X_val, y_val),
                    batch_size=16)
```

```
Epoch 1/100
215/215 [==============================] - 2s 3ms/step - loss: 0.0416 -
mean_squared_error: 0.0416 - val_loss: 0.0183 - val_mean_squared_error: 0.0183
Epoch 2/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0114 -
mean_squared_error: 0.0114 - val_loss: 0.0089 - val_mean_squared_error: 0.0089
Epoch 3/100
```

```
215/215 [==============================] - 1s 2ms/step - loss: 0.0107 -
mean_squared_error: 0.0107 - val_loss: 0.0194 - val_mean_squared_error: 0.0194
Epoch 4/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0081 -
mean_squared_error: 0.0081 - val_loss: 0.0099 - val_mean_squared_error: 0.0099
Epoch 5/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0087 -
mean_squared_error: 0.0087 - val_loss: 0.0164 - val_mean_squared_error: 0.0164
Epoch 6/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0071 -
mean_squared_error: 0.0071 - val_loss: 0.0260 - val_mean_squared_error: 0.0260
Epoch 7/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0075 -
mean_squared_error: 0.0075 - val_loss: 0.0345 - val_mean_squared_error: 0.0345
Epoch 8/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0066 -
mean_squared_error: 0.0066 - val_loss: 0.0299 - val_mean_squared_error: 0.0299
Epoch 9/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0068 -
mean_squared_error: 0.0068 - val_loss: 0.0222 - val_mean_squared_error: 0.0222
Epoch 10/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0074 - val_loss: 0.0139 - val_mean_squared_error: 0.0139
Epoch 11/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0053 -
mean_squared_error: 0.0053 - val_loss: 0.0184 - val_mean_squared_error: 0.0184
Epoch 12/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0048 -
mean_squared_error: 0.0048 - val_loss: 0.0358 - val_mean_squared_error: 0.0358
Epoch 13/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0051 -
mean_squared_error: 0.0051 - val_loss: 0.0319 - val_mean_squared_error: 0.0319
Epoch 14/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0051 -
mean_squared_error: 0.0051 - val_loss: 0.0296 - val_mean_squared_error: 0.0296
Epoch 15/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0051 -
mean_squared_error: 0.0051 - val_loss: 0.0277 - val_mean_squared_error: 0.0277
Epoch 16/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0052 -
mean_squared_error: 0.0052 - val_loss: 0.0179 - val_mean_squared_error: 0.0179
Epoch 17/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0044 -
mean_squared_error: 0.0044 - val_loss: 0.0274 - val_mean_squared_error: 0.0274
Epoch 18/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.0273 - val_mean_squared_error: 0.0273
Epoch 19/100
```

```
215/215 [==============================] - 1s 2ms/step - loss: 0.0043 -
mean_squared_error: 0.0043 - val_loss: 0.0442 - val_mean_squared_error: 0.0442
Epoch 20/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.0248 - val_mean_squared_error: 0.0248
Epoch 21/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0038 -
mean_squared_error: 0.0038 - val_loss: 0.0275 - val_mean_squared_error: 0.0275
Epoch 22/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0041 -
mean_squared_error: 0.0041 - val_loss: 0.0396 - val_mean_squared_error: 0.0396
Epoch 23/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0036 -
mean_squared_error: 0.0036 - val_loss: 0.0245 - val_mean_squared_error: 0.0245
Epoch 24/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0036 -
mean_squared_error: 0.0036 - val_loss: 0.0275 - val_mean_squared_error: 0.0275
Epoch 25/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0038 -
mean_squared_error: 0.0038 - val_loss: 0.0225 - val_mean_squared_error: 0.0225
Epoch 26/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.0284 - val_mean_squared_error: 0.0284
Epoch 27/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.0281 - val_mean_squared_error: 0.0281
Epoch 28/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0250 - val_mean_squared_error: 0.0250
Epoch 29/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0312 - val_mean_squared_error: 0.0312
Epoch 30/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0230 - val_mean_squared_error: 0.0230
Epoch 31/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0034 -
mean_squared_error: 0.0034 - val_loss: 0.0306 - val_mean_squared_error: 0.0306
Epoch 32/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0305 - val_mean_squared_error: 0.0305
Epoch 33/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0267 - val_mean_squared_error: 0.0267
Epoch 34/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0208 - val_mean_squared_error: 0.0208
Epoch 35/100
```

```
215/215 [==============================] - 1s 2ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0295 - val_mean_squared_error: 0.0295
Epoch 36/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0258 - val_mean_squared_error: 0.0258
Epoch 37/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0277 - val_mean_squared_error: 0.0277
Epoch 38/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0275 - val_mean_squared_error: 0.0275
Epoch 39/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0027 -
mean_squared_error: 0.0027 - val_loss: 0.0318 - val_mean_squared_error: 0.0318
Epoch 40/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0330 - val_mean_squared_error: 0.0330
Epoch 41/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0246 - val_mean_squared_error: 0.0246
Epoch 42/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0343 - val_mean_squared_error: 0.0343
Epoch 43/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0035 -
mean_squared_error: 0.0035 - val_loss: 0.0247 - val_mean_squared_error: 0.0247
Epoch 44/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0258 - val_mean_squared_error: 0.0258
Epoch 45/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0029 -
mean_squared_error: 0.0029 - val_loss: 0.0318 - val_mean_squared_error: 0.0318
Epoch 46/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0272 - val_mean_squared_error: 0.0272
Epoch 47/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0255 - val_mean_squared_error: 0.0255
Epoch 48/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0024 -
mean_squared_error: 0.0024 - val_loss: 0.0259 - val_mean_squared_error: 0.0259
Epoch 49/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0030 -
mean_squared_error: 0.0030 - val_loss: 0.0172 - val_mean_squared_error: 0.0172
Epoch 50/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0252 - val_mean_squared_error: 0.0252
Epoch 51/100
```

```
215/215 [==============================] - 1s 2ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0179 - val_mean_squared_error: 0.0179
Epoch 52/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0026 -
mean_squared_error: 0.0026 - val_loss: 0.0254 - val_mean_squared_error: 0.0254
Epoch 53/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0281 - val_mean_squared_error: 0.0281
Epoch 54/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0251 - val_mean_squared_error: 0.0251
Epoch 55/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0229 - val_mean_squared_error: 0.0229
Epoch 56/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0028 -
mean_squared_error: 0.0028 - val_loss: 0.0341 - val_mean_squared_error: 0.0341
Epoch 57/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0276 - val_mean_squared_error: 0.0276
Epoch 58/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0194 - val_mean_squared_error: 0.0194
Epoch 59/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0025 -
mean_squared_error: 0.0025 - val_loss: 0.0270 - val_mean_squared_error: 0.0270
Epoch 60/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0317 - val_mean_squared_error: 0.0317
Epoch 61/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0023 -
mean_squared_error: 0.0023 - val_loss: 0.0323 - val_mean_squared_error: 0.0323
Epoch 62/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0308 - val_mean_squared_error: 0.0308
Epoch 63/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0260 - val_mean_squared_error: 0.0260
Epoch 64/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0197 - val_mean_squared_error: 0.0197
Epoch 65/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0209 - val_mean_squared_error: 0.0209
Epoch 66/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0414 - val_mean_squared_error: 0.0414
Epoch 67/100
```

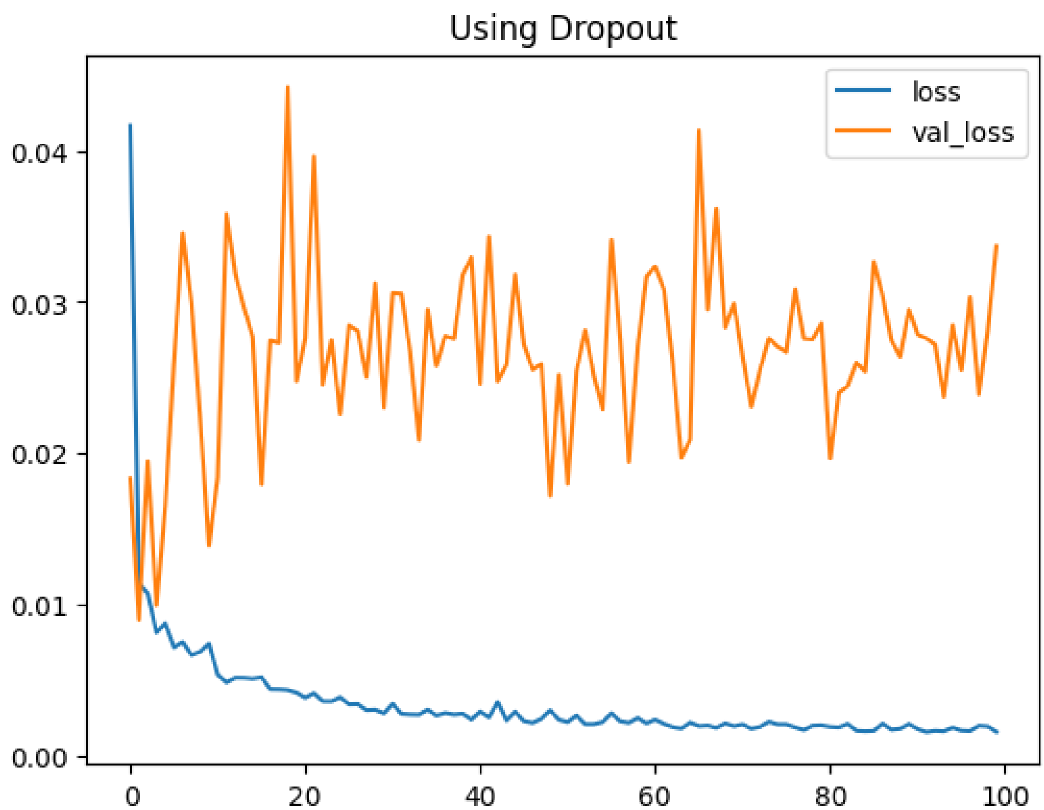
```
215/215 [==============================] - 1s 2ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0295 - val_mean_squared_error: 0.0295
Epoch 68/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0362 - val_mean_squared_error: 0.0362
Epoch 69/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0283 - val_mean_squared_error: 0.0283
Epoch 70/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0299 - val_mean_squared_error: 0.0299
Epoch 71/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0264 - val_mean_squared_error: 0.0264
Epoch 72/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0231 - val_mean_squared_error: 0.0231
Epoch 73/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0255 - val_mean_squared_error: 0.0255
Epoch 74/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0022 -
mean_squared_error: 0.0022 - val_loss: 0.0276 - val_mean_squared_error: 0.0276
Epoch 75/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0270 - val_mean_squared_error: 0.0270
Epoch 76/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0267 - val_mean_squared_error: 0.0267
Epoch 77/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0308 - val_mean_squared_error: 0.0308
Epoch 78/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0276 - val_mean_squared_error: 0.0276
Epoch 79/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0275 - val_mean_squared_error: 0.0275
Epoch 80/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0020 -
mean_squared_error: 0.0020 - val_loss: 0.0286 - val_mean_squared_error: 0.0286
Epoch 81/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0196 - val_mean_squared_error: 0.0196
Epoch 82/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0240 - val_mean_squared_error: 0.0240
Epoch 83/100
```

```
215/215 [==============================] - 1s 3ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0244 - val_mean_squared_error: 0.0244
Epoch 84/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0260 - val_mean_squared_error: 0.0260
Epoch 85/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0254 - val_mean_squared_error: 0.0254
Epoch 86/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0327 - val_mean_squared_error: 0.0327
Epoch 87/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0304 - val_mean_squared_error: 0.0304
Epoch 88/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0274 - val_mean_squared_error: 0.0274
Epoch 89/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0264 - val_mean_squared_error: 0.0264
Epoch 90/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0021 -
mean_squared_error: 0.0021 - val_loss: 0.0295 - val_mean_squared_error: 0.0295
Epoch 91/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0017 -
mean_squared_error: 0.0017 - val_loss: 0.0278 - val_mean_squared_error: 0.0278
Epoch 92/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0276 - val_mean_squared_error: 0.0276
Epoch 93/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0272 - val_mean_squared_error: 0.0272
Epoch 94/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0237 - val_mean_squared_error: 0.0237
Epoch 95/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0018 -
mean_squared_error: 0.0018 - val_loss: 0.0285 - val_mean_squared_error: 0.0285
Epoch 96/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0255 - val_mean_squared_error: 0.0255
Epoch 97/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0016 -
mean_squared_error: 0.0016 - val_loss: 0.0303 - val_mean_squared_error: 0.0303
Epoch 98/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0239 - val_mean_squared_error: 0.0239
Epoch 99/100
```

```
215/215 [==============================] - 1s 2ms/step - loss: 0.0019 -
mean_squared_error: 0.0019 - val_loss: 0.0281 - val_mean_squared_error: 0.0281
Epoch 100/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0015 -
mean_squared_error: 0.0015 - val_loss: 0.0337 - val_mean_squared_error: 0.0337
```

[56]:

```python
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['val_loss'], label='val_loss')
plt.legend()
plt.title('Using Dropout')
plt.show()
```



1.0.6 Implementing Regularization Techniques

[57]:

```python
import tensorflow as tf
from tensorflow.keras.layers import *

class L1Model(tf.keras.models.Model):

    def __init__(self):
        super().__init__()
```

```python
        self.dense_1 = Dense(128, activation=tf.nn.relu,␣
↪kernel_regularizer='l1')
        self.dense_2 = Dense(128, activation=tf.nn.relu,␣
↪kernel_regularizer='l1')
        self.dense_3 = Dense(128, activation=tf.nn.relu,␣
↪kernel_regularizer='l1')
        self.regression = Dense(1)

    def call(self, input_tensor):
        x = self.dense_1(input_tensor)
        x = self.dense_2(x)
        x = self.dense_3(x)
        return self.regression(x)

l1_model = L1Model()

l1_model.compile(loss=tf.keras.losses.MeanSquaredError(),
              optimizer=tf.keras.optimizers.Adam(),
              metrics=tf.keras.metrics.MeanSquaredError())

l1_history = l1_model.fit(X_train, y_train, epochs=100,
                    validation_data=(X_val, y_val),
                    batch_size=16)
```

```
Epoch 1/100
215/215 [==============================] - 2s 3ms/step - loss: 7.2121 -
mean_squared_error: 0.0405 - val_loss: 0.3964 - val_mean_squared_error: 0.0085
Epoch 2/100
215/215 [==============================] - 0s 2ms/step - loss: 0.2543 -
mean_squared_error: 0.0082 - val_loss: 0.1849 - val_mean_squared_error: 0.0072
Epoch 3/100
215/215 [==============================] - 1s 2ms/step - loss: 0.1620 -
mean_squared_error: 0.0055 - val_loss: 0.1463 - val_mean_squared_error: 0.0043
Epoch 4/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1372 -
mean_squared_error: 0.0038 - val_loss: 0.1292 - val_mean_squared_error: 0.0031
Epoch 5/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1230 -
mean_squared_error: 0.0031 - val_loss: 0.1167 - val_mean_squared_error: 0.0027
Epoch 6/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1113 -
mean_squared_error: 0.0027 - val_loss: 0.1056 - val_mean_squared_error: 0.0030
Epoch 7/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1000 -
mean_squared_error: 0.0022 - val_loss: 0.0950 - val_mean_squared_error: 0.0015
Epoch 8/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0911 -
```

```
mean_squared_error: 0.0013 - val_loss: 0.0897 - val_mean_squared_error: 0.0022
Epoch 9/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0859 -
mean_squared_error: 0.0011 - val_loss: 0.0834 - val_mean_squared_error:
9.0297e-04
Epoch 10/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0824 -
mean_squared_error: 0.0010 - val_loss: 0.0813 - val_mean_squared_error:
8.4753e-04
Epoch 11/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0810 -
mean_squared_error: 0.0010 - val_loss: 0.0805 - val_mean_squared_error: 0.0013
Epoch 12/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0799 -
mean_squared_error: 9.8843e-04 - val_loss: 0.0793 - val_mean_squared_error:
9.2994e-04
Epoch 13/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0788 -
mean_squared_error: 9.8294e-04 - val_loss: 0.0781 - val_mean_squared_error:
0.0011
Epoch 14/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0775 -
mean_squared_error: 9.8256e-04 - val_loss: 0.0769 - val_mean_squared_error:
0.0011
Epoch 15/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0759 -
mean_squared_error: 9.9057e-04 - val_loss: 0.0746 - val_mean_squared_error:
8.8222e-04
Epoch 16/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0742 -
mean_squared_error: 9.8294e-04 - val_loss: 0.0732 - val_mean_squared_error:
7.6673e-04
Epoch 17/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0727 -
mean_squared_error: 9.5648e-04 - val_loss: 0.0723 - val_mean_squared_error:
8.7215e-04
Epoch 18/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0719 -
mean_squared_error: 9.4531e-04 - val_loss: 0.0714 - val_mean_squared_error:
8.4945e-04
Epoch 19/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0709 -
mean_squared_error: 9.0838e-04 - val_loss: 0.0704 - val_mean_squared_error:
7.6477e-04
Epoch 20/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0700 -
mean_squared_error: 8.9048e-04 - val_loss: 0.0694 - val_mean_squared_error:
7.9038e-04
```

```
Epoch 21/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0688 -
mean_squared_error: 8.9029e-04 - val_loss: 0.0678 - val_mean_squared_error:
7.7143e-04
Epoch 22/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0673 -
mean_squared_error: 8.3625e-04 - val_loss: 0.0668 - val_mean_squared_error:
8.1486e-04
Epoch 23/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0663 -
mean_squared_error: 8.0778e-04 - val_loss: 0.0657 - val_mean_squared_error:
7.3139e-04
Epoch 24/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0655 -
mean_squared_error: 8.2595e-04 - val_loss: 0.0649 - val_mean_squared_error:
7.1591e-04
Epoch 25/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0647 -
mean_squared_error: 8.0382e-04 - val_loss: 0.0647 - val_mean_squared_error:
7.3816e-04
Epoch 26/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0646 -
mean_squared_error: 8.3270e-04 - val_loss: 0.0646 - val_mean_squared_error:
7.5453e-04
Epoch 27/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0644 -
mean_squared_error: 8.2858e-04 - val_loss: 0.0642 - val_mean_squared_error:
8.0925e-04
Epoch 28/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0643 -
mean_squared_error: 8.4370e-04 - val_loss: 0.0639 - val_mean_squared_error:
7.0287e-04
Epoch 29/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0642 -
mean_squared_error: 8.3197e-04 - val_loss: 0.0639 - val_mean_squared_error:
7.0053e-04
Epoch 30/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0640 -
mean_squared_error: 8.2943e-04 - val_loss: 0.0644 - val_mean_squared_error:
8.5973e-04
Epoch 31/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0639 -
mean_squared_error: 8.4376e-04 - val_loss: 0.0637 - val_mean_squared_error:
7.4042e-04
Epoch 32/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0637 -
mean_squared_error: 7.9653e-04 - val_loss: 0.0636 - val_mean_squared_error:
7.0302e-04
```

```
Epoch 33/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0637 -
mean_squared_error: 8.6351e-04 - val_loss: 0.0633 - val_mean_squared_error:
6.8926e-04
Epoch 34/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0634 -
mean_squared_error: 8.0367e-04 - val_loss: 0.0633 - val_mean_squared_error:
7.3087e-04
Epoch 35/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0633 -
mean_squared_error: 7.9714e-04 - val_loss: 0.0631 - val_mean_squared_error:
8.3742e-04
Epoch 36/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0633 -
mean_squared_error: 8.1805e-04 - val_loss: 0.0631 - val_mean_squared_error:
6.9430e-04
Epoch 37/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0631 -
mean_squared_error: 7.7683e-04 - val_loss: 0.0630 - val_mean_squared_error:
7.6747e-04
Epoch 38/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0630 -
mean_squared_error: 7.8138e-04 - val_loss: 0.0628 - val_mean_squared_error:
7.1577e-04
Epoch 39/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0630 -
mean_squared_error: 8.5460e-04 - val_loss: 0.0627 - val_mean_squared_error:
7.3559e-04
Epoch 40/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0628 -
mean_squared_error: 8.0188e-04 - val_loss: 0.0627 - val_mean_squared_error:
7.1969e-04
Epoch 41/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0627 -
mean_squared_error: 8.1977e-04 - val_loss: 0.0631 - val_mean_squared_error:
9.9769e-04
Epoch 42/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0626 -
mean_squared_error: 7.8323e-04 - val_loss: 0.0627 - val_mean_squared_error:
6.9471e-04
Epoch 43/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0626 -
mean_squared_error: 8.5058e-04 - val_loss: 0.0627 - val_mean_squared_error:
7.1187e-04
Epoch 44/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0625 -
mean_squared_error: 8.4141e-04 - val_loss: 0.0632 - val_mean_squared_error:
0.0013
```

```
Epoch 45/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0624 -
mean_squared_error: 8.4909e-04 - val_loss: 0.0620 - val_mean_squared_error:
7.6127e-04
Epoch 46/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0622 -
mean_squared_error: 7.9771e-04 - val_loss: 0.0619 - val_mean_squared_error:
7.4541e-04
Epoch 47/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0623 -
mean_squared_error: 8.8859e-04 - val_loss: 0.0619 - val_mean_squared_error:
8.2490e-04
Epoch 48/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0621 -
mean_squared_error: 8.1442e-04 - val_loss: 0.0620 - val_mean_squared_error:
6.9062e-04
Epoch 49/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0620 -
mean_squared_error: 7.9881e-04 - val_loss: 0.0621 - val_mean_squared_error:
8.5215e-04
Epoch 50/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0621 -
mean_squared_error: 9.2395e-04 - val_loss: 0.0623 - val_mean_squared_error:
0.0011
Epoch 51/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0618 -
mean_squared_error: 8.0311e-04 - val_loss: 0.0618 - val_mean_squared_error:
8.5392e-04
Epoch 52/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0618 -
mean_squared_error: 8.5788e-04 - val_loss: 0.0617 - val_mean_squared_error:
7.3052e-04
Epoch 53/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0618 -
mean_squared_error: 8.5138e-04 - val_loss: 0.0618 - val_mean_squared_error:
0.0011
Epoch 54/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0617 -
mean_squared_error: 8.3620e-04 - val_loss: 0.0618 - val_mean_squared_error:
7.3590e-04
Epoch 55/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0616 -
mean_squared_error: 8.6990e-04 - val_loss: 0.0618 - val_mean_squared_error:
7.0386e-04
Epoch 56/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0615 -
mean_squared_error: 8.0939e-04 - val_loss: 0.0614 - val_mean_squared_error:
7.4789e-04
```

```
Epoch 57/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0614 -
mean_squared_error: 8.2566e-04 - val_loss: 0.0613 - val_mean_squared_error:
7.6602e-04
Epoch 58/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0614 -
mean_squared_error: 8.6670e-04 - val_loss: 0.0612 - val_mean_squared_error:
9.5267e-04
Epoch 59/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0613 -
mean_squared_error: 8.5332e-04 - val_loss: 0.0613 - val_mean_squared_error:
9.3917e-04
Epoch 60/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0614 -
mean_squared_error: 9.5601e-04 - val_loss: 0.0613 - val_mean_squared_error:
8.2042e-04
Epoch 61/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0612 -
mean_squared_error: 8.4711e-04 - val_loss: 0.0631 - val_mean_squared_error:
0.0025
Epoch 62/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0612 -
mean_squared_error: 9.0463e-04 - val_loss: 0.0612 - val_mean_squared_error:
8.6022e-04
Epoch 63/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0611 -
mean_squared_error: 8.1979e-04 - val_loss: 0.0609 - val_mean_squared_error:
9.4111e-04
Epoch 64/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0610 -
mean_squared_error: 8.4156e-04 - val_loss: 0.0609 - val_mean_squared_error:
9.4281e-04
Epoch 65/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0610 -
mean_squared_error: 8.6410e-04 - val_loss: 0.0609 - val_mean_squared_error:
8.2586e-04
Epoch 66/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0609 -
mean_squared_error: 8.2647e-04 - val_loss: 0.0618 - val_mean_squared_error:
0.0013
Epoch 67/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0609 -
mean_squared_error: 9.1274e-04 - val_loss: 0.0611 - val_mean_squared_error:
9.1160e-04
Epoch 68/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0608 -
mean_squared_error: 8.5193e-04 - val_loss: 0.0611 - val_mean_squared_error:
9.7561e-04
```

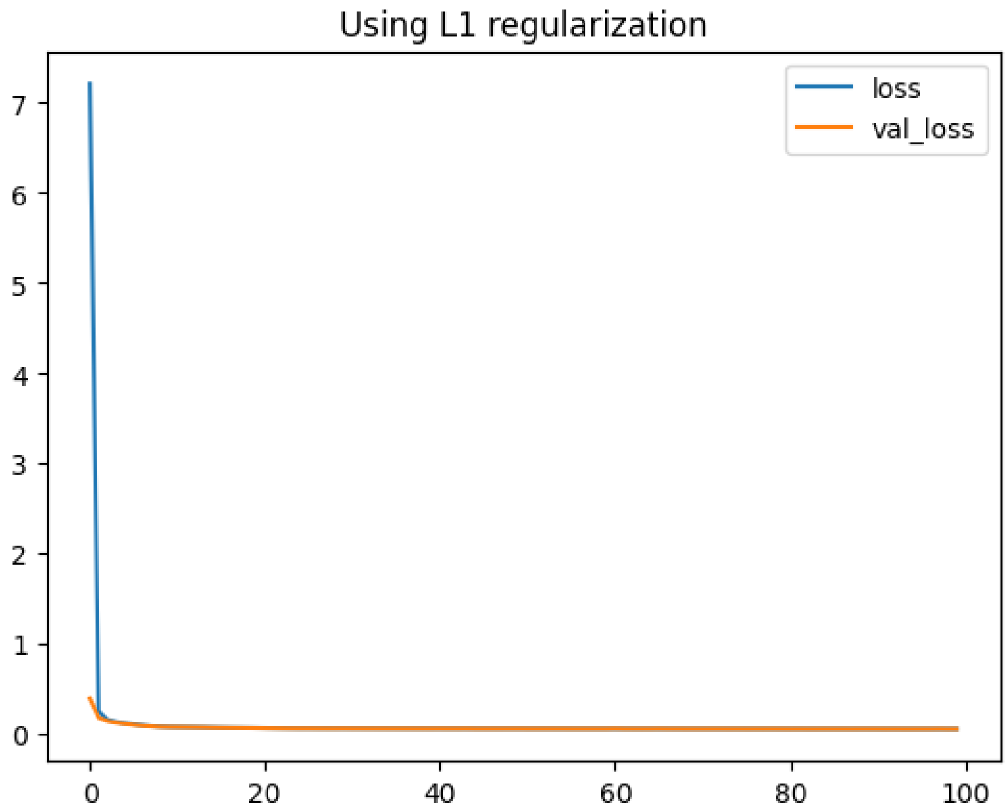
```
Epoch 69/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0608 -
mean_squared_error: 8.5900e-04 - val_loss: 0.0606 - val_mean_squared_error:
7.4742e-04
Epoch 70/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0607 -
mean_squared_error: 8.6567e-04 - val_loss: 0.0605 - val_mean_squared_error:
8.6936e-04
Epoch 71/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0606 -
mean_squared_error: 8.4867e-04 - val_loss: 0.0604 - val_mean_squared_error:
7.9037e-04
Epoch 72/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0606 -
mean_squared_error: 8.5863e-04 - val_loss: 0.0607 - val_mean_squared_error:
7.6843e-04
Epoch 73/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0605 -
mean_squared_error: 8.6384e-04 - val_loss: 0.0608 - val_mean_squared_error:
9.9880e-04
Epoch 74/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0605 -
mean_squared_error: 8.3326e-04 - val_loss: 0.0604 - val_mean_squared_error:
8.3538e-04
Epoch 75/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0604 -
mean_squared_error: 8.8271e-04 - val_loss: 0.0605 - val_mean_squared_error:
9.7623e-04
Epoch 76/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0603 -
mean_squared_error: 8.4101e-04 - val_loss: 0.0601 - val_mean_squared_error:
7.5234e-04
Epoch 77/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0603 -
mean_squared_error: 8.5626e-04 - val_loss: 0.0604 - val_mean_squared_error:
0.0012
Epoch 78/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0603 -
mean_squared_error: 8.8459e-04 - val_loss: 0.0603 - val_mean_squared_error:
7.8470e-04
Epoch 79/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0602 -
mean_squared_error: 8.9102e-04 - val_loss: 0.0606 - val_mean_squared_error:
8.6372e-04
Epoch 80/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0602 -
mean_squared_error: 8.4709e-04 - val_loss: 0.0602 - val_mean_squared_error:
7.4294e-04
```

```
Epoch 81/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0601 -
mean_squared_error: 8.5183e-04 - val_loss: 0.0598 - val_mean_squared_error:
8.5463e-04
Epoch 82/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0601 -
mean_squared_error: 8.8159e-04 - val_loss: 0.0600 - val_mean_squared_error:
9.6857e-04
Epoch 83/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0600 -
mean_squared_error: 8.2055e-04 - val_loss: 0.0598 - val_mean_squared_error:
7.4947e-04
Epoch 84/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0600 -
mean_squared_error: 8.9362e-04 - val_loss: 0.0598 - val_mean_squared_error:
7.3007e-04
Epoch 85/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0599 -
mean_squared_error: 8.3967e-04 - val_loss: 0.0601 - val_mean_squared_error:
8.5161e-04
Epoch 86/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0599 -
mean_squared_error: 9.0702e-04 - val_loss: 0.0599 - val_mean_squared_error:
8.1407e-04
Epoch 87/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0599 -
mean_squared_error: 8.6647e-04 - val_loss: 0.0600 - val_mean_squared_error:
0.0011
Epoch 88/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0598 -
mean_squared_error: 8.7348e-04 - val_loss: 0.0597 - val_mean_squared_error:
8.1828e-04
Epoch 89/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0598 -
mean_squared_error: 8.9150e-04 - val_loss: 0.0601 - val_mean_squared_error:
0.0013
Epoch 90/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0597 -
mean_squared_error: 8.4389e-04 - val_loss: 0.0601 - val_mean_squared_error:
0.0011
Epoch 91/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0597 -
mean_squared_error: 8.4919e-04 - val_loss: 0.0601 - val_mean_squared_error:
9.6578e-04
Epoch 92/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0597 -
mean_squared_error: 9.0407e-04 - val_loss: 0.0595 - val_mean_squared_error:
7.9900e-04
```

```
Epoch 93/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0596 -
mean_squared_error: 8.9673e-04 - val_loss: 0.0598 - val_mean_squared_error:
0.0012
Epoch 94/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0595 -
mean_squared_error: 8.5749e-04 - val_loss: 0.0594 - val_mean_squared_error:
7.5380e-04
Epoch 95/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0596 -
mean_squared_error: 9.1940e-04 - val_loss: 0.0594 - val_mean_squared_error:
0.0010
Epoch 96/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0595 -
mean_squared_error: 8.9953e-04 - val_loss: 0.0595 - val_mean_squared_error:
7.4615e-04
Epoch 97/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0594 -
mean_squared_error: 8.4257e-04 - val_loss: 0.0596 - val_mean_squared_error:
7.3995e-04
Epoch 98/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0594 -
mean_squared_error: 8.5987e-04 - val_loss: 0.0605 - val_mean_squared_error:
0.0018
Epoch 99/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0594 -
mean_squared_error: 8.8091e-04 - val_loss: 0.0592 - val_mean_squared_error:
8.2234e-04
Epoch 100/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0592 -
mean_squared_error: 8.2429e-04 - val_loss: 0.0593 - val_mean_squared_error:
8.8268e-04
```

[58]:

```
plt.plot(l1_history.history['loss'], label='loss')
plt.plot(l1_history.history['val_loss'], label='val_loss')
plt.legend()
plt.title('Using L1 regularization')
plt.show()
```



[59]:
```
import tensorflow as tf
from tensorflow.keras.layers import *

class L2Model(tf.keras.models.Model):

    def __init__(self):
        super().__init__()
        self.dense_1 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l2')
        self.dense_2 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l2')
        self.dense_3 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l2')
        self.regression = Dense(1)

    def call(self, input_tensor):
        x = self.dense_1(input_tensor)
        x = self.dense_2(x)
        x = self.dense_3(x)
        return self.regression(x)
```

```
l2_model = L2Model()

l2_model.compile(loss=tf.keras.losses.MeanSquaredError(),
              optimizer=tf.keras.optimizers.Adam(),
              metrics=tf.keras.metrics.MeanSquaredError())

l2_history = l2_model.fit(X_train, y_train, epochs=100,
                    validation_data=(X_val, y_val),
                    batch_size=16)
```

```
Epoch 1/100
215/215 [==============================] - 2s 4ms/step - loss: 0.9309 -
mean_squared_error: 0.0213 - val_loss: 0.2177 - val_mean_squared_error: 0.0020
Epoch 2/100
215/215 [==============================] - 1s 2ms/step - loss: 0.1151 -
mean_squared_error: 0.0022 - val_loss: 0.0603 - val_mean_squared_error: 0.0025
Epoch 3/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0435 -
mean_squared_error: 0.0027 - val_loss: 0.0318 - val_mean_squared_error: 0.0019
Epoch 4/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0274 -
mean_squared_error: 0.0024 - val_loss: 0.0236 - val_mean_squared_error: 0.0021
Epoch 5/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0216 -
mean_squared_error: 0.0019 - val_loss: 0.0216 - val_mean_squared_error: 0.0039
Epoch 6/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0196 -
mean_squared_error: 0.0027 - val_loss: 0.0178 - val_mean_squared_error: 0.0018
Epoch 7/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0175 -
mean_squared_error: 0.0024 - val_loss: 0.0161 - val_mean_squared_error: 0.0015
Epoch 8/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0168 -
mean_squared_error: 0.0029 - val_loss: 0.0172 - val_mean_squared_error: 0.0038
Epoch 9/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0152 -
mean_squared_error: 0.0023 - val_loss: 0.0138 - val_mean_squared_error: 0.0013
Epoch 10/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0140 -
mean_squared_error: 0.0019 - val_loss: 0.0152 - val_mean_squared_error: 0.0036
Epoch 11/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0134 -
mean_squared_error: 0.0020 - val_loss: 0.0123 - val_mean_squared_error: 0.0013
Epoch 12/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0126 -
mean_squared_error: 0.0019 - val_loss: 0.0130 - val_mean_squared_error: 0.0028
Epoch 13/100
```

```
215/215 [==============================] - 0s 2ms/step - loss: 0.0118 -
mean_squared_error: 0.0017 - val_loss: 0.0122 - val_mean_squared_error: 0.0025
Epoch 14/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0110 -
mean_squared_error: 0.0015 - val_loss: 0.0151 - val_mean_squared_error: 0.0055
Epoch 15/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0113 -
mean_squared_error: 0.0022 - val_loss: 0.0134 - val_mean_squared_error: 0.0045
Epoch 16/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0103 -
mean_squared_error: 0.0015 - val_loss: 0.0100 - val_mean_squared_error: 0.0014
Epoch 17/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0109 -
mean_squared_error: 0.0024 - val_loss: 0.0096 - val_mean_squared_error: 0.0012
Epoch 18/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0099 -
mean_squared_error: 0.0015 - val_loss: 0.0101 - val_mean_squared_error: 0.0019
Epoch 19/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0098 -
mean_squared_error: 0.0017 - val_loss: 0.0090 - val_mean_squared_error:
9.6336e-04
Epoch 20/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0102 -
mean_squared_error: 0.0021 - val_loss: 0.0108 - val_mean_squared_error: 0.0030
Epoch 21/100
215/215 [==============================] - 1s 4ms/step - loss: 0.0098 -
mean_squared_error: 0.0019 - val_loss: 0.0093 - val_mean_squared_error: 0.0014
Epoch 22/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0095 -
mean_squared_error: 0.0017 - val_loss: 0.0096 - val_mean_squared_error: 0.0016
Epoch 23/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0092 -
mean_squared_error: 0.0014 - val_loss: 0.0092 - val_mean_squared_error: 0.0015
Epoch 24/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0097 -
mean_squared_error: 0.0020 - val_loss: 0.0098 - val_mean_squared_error: 0.0020
Epoch 25/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0094 -
mean_squared_error: 0.0017 - val_loss: 0.0086 - val_mean_squared_error: 0.0011
Epoch 26/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0092 -
mean_squared_error: 0.0016 - val_loss: 0.0090 - val_mean_squared_error: 0.0016
Epoch 27/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0092 -
mean_squared_error: 0.0017 - val_loss: 0.0089 - val_mean_squared_error: 0.0013
Epoch 28/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0090 -
mean_squared_error: 0.0015 - val_loss: 0.0088 - val_mean_squared_error: 0.0013
```

```
Epoch 29/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0088 -
mean_squared_error: 0.0014 - val_loss: 0.0095 - val_mean_squared_error: 0.0022
Epoch 30/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0089 -
mean_squared_error: 0.0016 - val_loss: 0.0086 - val_mean_squared_error: 0.0013
Epoch 31/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0085 -
mean_squared_error: 0.0013 - val_loss: 0.0084 - val_mean_squared_error: 0.0012
Epoch 32/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0088 -
mean_squared_error: 0.0016 - val_loss: 0.0082 - val_mean_squared_error:
9.9968e-04
Epoch 33/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0087 -
mean_squared_error: 0.0015 - val_loss: 0.0083 - val_mean_squared_error: 0.0012
Epoch 34/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0086 -
mean_squared_error: 0.0015 - val_loss: 0.0080 - val_mean_squared_error:
9.1257e-04
Epoch 35/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0086 -
mean_squared_error: 0.0015 - val_loss: 0.0080 - val_mean_squared_error:
9.6763e-04
Epoch 36/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0086 -
mean_squared_error: 0.0016 - val_loss: 0.0116 - val_mean_squared_error: 0.0046
Epoch 37/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0090 -
mean_squared_error: 0.0020 - val_loss: 0.0090 - val_mean_squared_error: 0.0020
Epoch 38/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0083 -
mean_squared_error: 0.0014 - val_loss: 0.0079 - val_mean_squared_error: 0.0010
Epoch 39/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0085 -
mean_squared_error: 0.0016 - val_loss: 0.0080 - val_mean_squared_error: 0.0010
Epoch 40/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0085 -
mean_squared_error: 0.0016 - val_loss: 0.0085 - val_mean_squared_error: 0.0016
Epoch 41/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0082 -
mean_squared_error: 0.0014 - val_loss: 0.0079 - val_mean_squared_error: 0.0012
Epoch 42/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0084 -
mean_squared_error: 0.0016 - val_loss: 0.0089 - val_mean_squared_error: 0.0022
Epoch 43/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0084 -
mean_squared_error: 0.0017 - val_loss: 0.0089 - val_mean_squared_error: 0.0022
```

```
Epoch 44/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0081 -
mean_squared_error: 0.0014 - val_loss: 0.0076 - val_mean_squared_error:
9.3285e-04
Epoch 45/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0082 -
mean_squared_error: 0.0016 - val_loss: 0.0076 - val_mean_squared_error:
9.4305e-04
Epoch 46/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0084 -
mean_squared_error: 0.0017 - val_loss: 0.0083 - val_mean_squared_error: 0.0016
Epoch 47/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0013 - val_loss: 0.0077 - val_mean_squared_error: 0.0011
Epoch 48/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0014 - val_loss: 0.0076 - val_mean_squared_error: 0.0011
Epoch 49/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0014 - val_loss: 0.0079 - val_mean_squared_error: 0.0013
Epoch 50/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0015 - val_loss: 0.0075 - val_mean_squared_error: 0.0011
Epoch 51/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0085 -
mean_squared_error: 0.0020 - val_loss: 0.0076 - val_mean_squared_error: 0.0012
Epoch 52/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0014 - val_loss: 0.0089 - val_mean_squared_error: 0.0025
Epoch 53/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0081 -
mean_squared_error: 0.0017 - val_loss: 0.0072 - val_mean_squared_error:
8.4011e-04
Epoch 54/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0077 -
mean_squared_error: 0.0013 - val_loss: 0.0072 - val_mean_squared_error:
8.2325e-04
Epoch 55/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0080 -
mean_squared_error: 0.0017 - val_loss: 0.0090 - val_mean_squared_error: 0.0026
Epoch 56/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0077 -
mean_squared_error: 0.0014 - val_loss: 0.0073 - val_mean_squared_error: 0.0010
Epoch 57/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0080 -
mean_squared_error: 0.0017 - val_loss: 0.0080 - val_mean_squared_error: 0.0018
Epoch 58/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0076 -
```

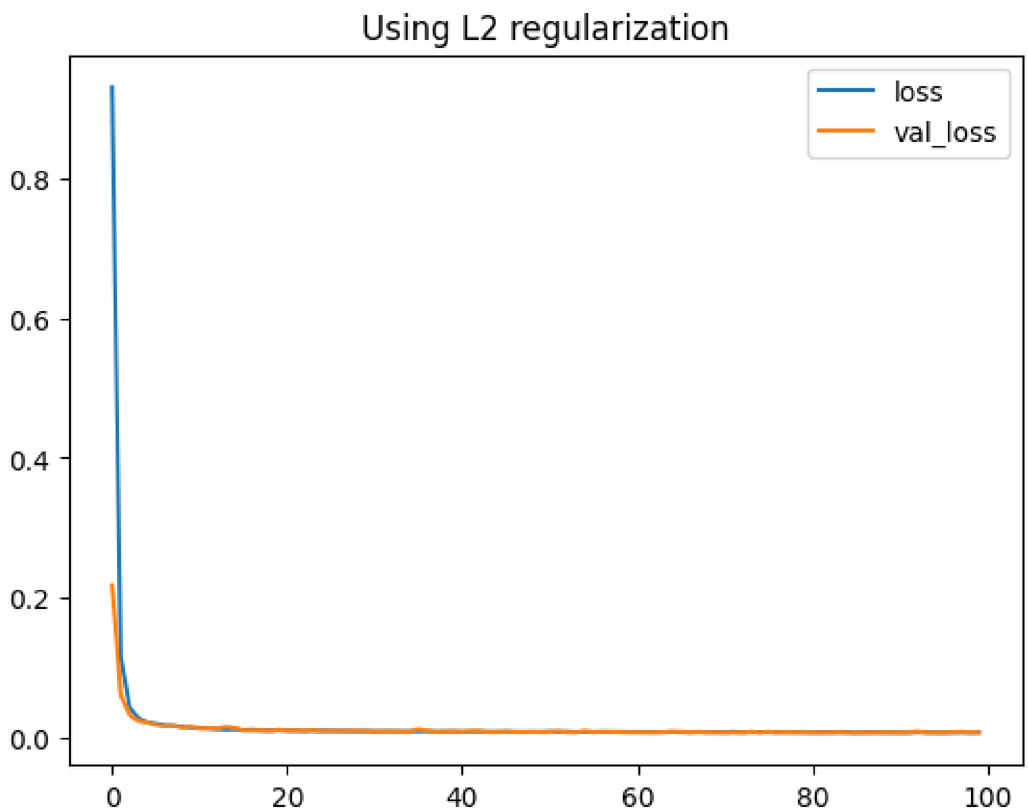
```
mean_squared_error: 0.0014 - val_loss: 0.0080 - val_mean_squared_error: 0.0018
Epoch 59/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0017 - val_loss: 0.0075 - val_mean_squared_error: 0.0012
Epoch 60/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0076 -
mean_squared_error: 0.0014 - val_loss: 0.0073 - val_mean_squared_error: 0.0011
Epoch 61/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0077 -
mean_squared_error: 0.0016 - val_loss: 0.0073 - val_mean_squared_error: 0.0012
Epoch 62/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0077 -
mean_squared_error: 0.0015 - val_loss: 0.0071 - val_mean_squared_error:
9.1998e-04
Epoch 63/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0075 -
mean_squared_error: 0.0014 - val_loss: 0.0071 - val_mean_squared_error:
9.7355e-04
Epoch 64/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0076 -
mean_squared_error: 0.0015 - val_loss: 0.0075 - val_mean_squared_error: 0.0014
Epoch 65/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0019 - val_loss: 0.0081 - val_mean_squared_error: 0.0022
Epoch 66/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0075 -
mean_squared_error: 0.0014 - val_loss: 0.0080 - val_mean_squared_error: 0.0021
Epoch 67/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0013 - val_loss: 0.0072 - val_mean_squared_error: 0.0012
Epoch 68/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0077 -
mean_squared_error: 0.0017 - val_loss: 0.0078 - val_mean_squared_error: 0.0019
Epoch 69/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0013 - val_loss: 0.0071 - val_mean_squared_error: 0.0012
Epoch 70/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0076 -
mean_squared_error: 0.0017 - val_loss: 0.0069 - val_mean_squared_error: 0.0010
Epoch 71/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0014 - val_loss: 0.0068 - val_mean_squared_error:
8.5620e-04
Epoch 72/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0079 -
mean_squared_error: 0.0020 - val_loss: 0.0069 - val_mean_squared_error: 0.0010
Epoch 73/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0072 -
```

```
mean_squared_error: 0.0013 - val_loss: 0.0068 - val_mean_squared_error:
9.7527e-04
Epoch 74/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0015 - val_loss: 0.0081 - val_mean_squared_error: 0.0022
Epoch 75/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0076 -
mean_squared_error: 0.0017 - val_loss: 0.0068 - val_mean_squared_error:
9.3896e-04
Epoch 76/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0015 - val_loss: 0.0080 - val_mean_squared_error: 0.0021
Epoch 77/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0016 - val_loss: 0.0068 - val_mean_squared_error:
9.9328e-04
Epoch 78/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0071 -
mean_squared_error: 0.0013 - val_loss: 0.0076 - val_mean_squared_error: 0.0017
Epoch 79/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0074 -
mean_squared_error: 0.0016 - val_loss: 0.0069 - val_mean_squared_error: 0.0012
Epoch 80/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0071 -
mean_squared_error: 0.0014 - val_loss: 0.0071 - val_mean_squared_error: 0.0013
Epoch 81/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0070 -
mean_squared_error: 0.0013 - val_loss: 0.0066 - val_mean_squared_error:
9.5890e-04
Epoch 82/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0016 - val_loss: 0.0066 - val_mean_squared_error:
9.0516e-04
Epoch 83/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0016 - val_loss: 0.0067 - val_mean_squared_error: 0.0010
Epoch 84/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0071 -
mean_squared_error: 0.0014 - val_loss: 0.0076 - val_mean_squared_error: 0.0019
Epoch 85/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0017 - val_loss: 0.0065 - val_mean_squared_error:
8.5429e-04
Epoch 86/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0070 -
mean_squared_error: 0.0013 - val_loss: 0.0066 - val_mean_squared_error:
9.4299e-04
Epoch 87/100
```

```
215/215 [==============================] - 0s 2ms/step - loss: 0.0072 -
mean_squared_error: 0.0016 - val_loss: 0.0065 - val_mean_squared_error:
8.7774e-04
Epoch 88/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0075 -
mean_squared_error: 0.0019 - val_loss: 0.0065 - val_mean_squared_error:
8.6753e-04
Epoch 89/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0069 -
mean_squared_error: 0.0013 - val_loss: 0.0071 - val_mean_squared_error: 0.0016
Epoch 90/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0017 - val_loss: 0.0066 - val_mean_squared_error: 0.0010
Epoch 91/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0069 -
mean_squared_error: 0.0014 - val_loss: 0.0067 - val_mean_squared_error: 0.0012
Epoch 92/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0068 -
mean_squared_error: 0.0013 - val_loss: 0.0073 - val_mean_squared_error: 0.0018
Epoch 93/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0018 - val_loss: 0.0085 - val_mean_squared_error: 0.0029
Epoch 94/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0073 -
mean_squared_error: 0.0018 - val_loss: 0.0066 - val_mean_squared_error: 0.0012
Epoch 95/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0069 -
mean_squared_error: 0.0014 - val_loss: 0.0069 - val_mean_squared_error: 0.0015
Epoch 96/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0070 -
mean_squared_error: 0.0015 - val_loss: 0.0064 - val_mean_squared_error:
8.6344e-04
Epoch 97/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0069 -
mean_squared_error: 0.0014 - val_loss: 0.0074 - val_mean_squared_error: 0.0021
Epoch 98/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0070 -
mean_squared_error: 0.0016 - val_loss: 0.0080 - val_mean_squared_error: 0.0024
Epoch 99/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0068 -
mean_squared_error: 0.0014 - val_loss: 0.0070 - val_mean_squared_error: 0.0016
Epoch 100/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0072 -
mean_squared_error: 0.0018 - val_loss: 0.0069 - val_mean_squared_error: 0.0015
```

[60]:
```
plt.plot(l2_history.history['loss'], label='loss')
plt.plot(l2_history.history['val_loss'], label='val_loss')
```

```
plt.legend()
plt.title('Using L2 regularization')
plt.show()
```



[62]:

```
import tensorflow as tf
from tensorflow.keras.layers import *

class ElasticModel(tf.keras.models.Model):

    def __init__(self):
        super().__init__()
        self.dense_1 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l1_l2')
        self.dense_2 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l1_l2')
        self.dense_3 = Dense(128, activation=tf.nn.relu,␣
 ↪kernel_regularizer='l1_l2')
        self.regression = Dense(1)

    def call(self, input_tensor):
```

```
        x = self.dense_1(input_tensor)
        x = self.dense_2(x)
        x = self.dense_3(x)
        return self.regression(x)

elastic_model = ElasticModel()

elastic_model.compile(loss=tf.keras.losses.MeanSquaredError(),
                      optimizer=tf.keras.optimizers.Adam(),
                      metrics=tf.keras.metrics.MeanSquaredError())

elastic_history = elastic_model.fit(X_train, y_train, epochs=100,
                                    validation_data=(X_val, y_val),
                                    batch_size=16)
```

```
Epoch 1/100
215/215 [==============================] - 2s 3ms/step - loss: 7.6227 -
mean_squared_error: 0.0392 - val_loss: 0.3149 - val_mean_squared_error: 0.0098
Epoch 2/100
215/215 [==============================] - 0s 2ms/step - loss: 0.2195 -
mean_squared_error: 0.0088 - val_loss: 0.1720 - val_mean_squared_error: 0.0069
Epoch 3/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1479 -
mean_squared_error: 0.0039 - val_loss: 0.1317 - val_mean_squared_error: 0.0024
Epoch 4/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1243 -
mean_squared_error: 0.0021 - val_loss: 0.1174 - val_mean_squared_error: 0.0014
Epoch 5/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1128 -
mean_squared_error: 0.0014 - val_loss: 0.1090 - val_mean_squared_error: 0.0014
Epoch 6/100
215/215 [==============================] - 0s 2ms/step - loss: 0.1068 -
mean_squared_error: 0.0013 - val_loss: 0.1044 - val_mean_squared_error: 0.0010
Epoch 7/100
215/215 [==============================] - 1s 3ms/step - loss: 0.1029 -
mean_squared_error: 0.0013 - val_loss: 0.1005 - val_mean_squared_error: 0.0011
Epoch 8/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0988 -
mean_squared_error: 0.0012 - val_loss: 0.0969 - val_mean_squared_error:
8.5473e-04
Epoch 9/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0962 -
mean_squared_error: 0.0012 - val_loss: 0.0950 - val_mean_squared_error: 0.0010
Epoch 10/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0943 -
mean_squared_error: 0.0012 - val_loss: 0.0927 - val_mean_squared_error: 0.0011
Epoch 11/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0918 -
```

```
mean_squared_error: 0.0012 - val_loss: 0.0903 - val_mean_squared_error:
9.2670e-04
Epoch 12/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0896 -
mean_squared_error: 0.0012 - val_loss: 0.0886 - val_mean_squared_error: 0.0011
Epoch 13/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0880 -
mean_squared_error: 0.0012 - val_loss: 0.0868 - val_mean_squared_error: 0.0011
Epoch 14/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0861 -
mean_squared_error: 0.0012 - val_loss: 0.0848 - val_mean_squared_error: 0.0012
Epoch 15/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0840 -
mean_squared_error: 0.0012 - val_loss: 0.0838 - val_mean_squared_error: 0.0015
Epoch 16/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0824 -
mean_squared_error: 0.0012 - val_loss: 0.0812 - val_mean_squared_error:
9.0415e-04
Epoch 17/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0810 -
mean_squared_error: 0.0011 - val_loss: 0.0800 - val_mean_squared_error:
9.3448e-04
Epoch 18/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0801 -
mean_squared_error: 0.0012 - val_loss: 0.0793 - val_mean_squared_error:
9.7038e-04
Epoch 19/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0791 -
mean_squared_error: 0.0014 - val_loss: 0.0779 - val_mean_squared_error: 0.0013
Epoch 20/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0771 -
mean_squared_error: 0.0011 - val_loss: 0.0763 - val_mean_squared_error:
9.9006e-04
Epoch 21/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0757 -
mean_squared_error: 0.0011 - val_loss: 0.0751 - val_mean_squared_error: 0.0011
Epoch 22/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0746 -
mean_squared_error: 0.0011 - val_loss: 0.0742 - val_mean_squared_error: 0.0015
Epoch 23/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0736 -
mean_squared_error: 0.0010 - val_loss: 0.0730 - val_mean_squared_error:
8.9859e-04
Epoch 24/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0733 -
mean_squared_error: 0.0011 - val_loss: 0.0735 - val_mean_squared_error: 0.0014
Epoch 25/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0729 -
```

```
mean_squared_error: 0.0010 - val_loss: 0.0724 - val_mean_squared_error:
8.6496e-04
Epoch 26/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0726 -
mean_squared_error: 0.0010 - val_loss: 0.0723 - val_mean_squared_error:
8.5884e-04
Epoch 27/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0724 -
mean_squared_error: 0.0011 - val_loss: 0.0722 - val_mean_squared_error:
9.0559e-04
Epoch 28/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0723 -
mean_squared_error: 0.0011 - val_loss: 0.0715 - val_mean_squared_error:
8.5457e-04
Epoch 29/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0719 -
mean_squared_error: 0.0011 - val_loss: 0.0715 - val_mean_squared_error:
9.1511e-04
Epoch 30/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0716 -
mean_squared_error: 0.0010 - val_loss: 0.0726 - val_mean_squared_error: 0.0019
Epoch 31/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0715 -
mean_squared_error: 0.0010 - val_loss: 0.0716 - val_mean_squared_error: 0.0012
Epoch 32/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0714 -
mean_squared_error: 0.0011 - val_loss: 0.0710 - val_mean_squared_error:
7.9894e-04
Epoch 33/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0710 -
mean_squared_error: 0.0010 - val_loss: 0.0708 - val_mean_squared_error:
9.6077e-04
Epoch 34/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0708 -
mean_squared_error: 0.0010 - val_loss: 0.0704 - val_mean_squared_error:
8.1780e-04
Epoch 35/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0707 -
mean_squared_error: 0.0010 - val_loss: 0.0706 - val_mean_squared_error:
9.4292e-04
Epoch 36/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0705 -
mean_squared_error: 9.9827e-04 - val_loss: 0.0704 - val_mean_squared_error:
7.9835e-04
Epoch 37/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0705 -
mean_squared_error: 0.0011 - val_loss: 0.0698 - val_mean_squared_error:
8.0782e-04
```

```
Epoch 38/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0702 -
mean_squared_error: 0.0010 - val_loss: 0.0699 - val_mean_squared_error:
9.0186e-04
Epoch 39/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0701 -
mean_squared_error: 0.0010 - val_loss: 0.0696 - val_mean_squared_error:
8.9147e-04
Epoch 40/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0699 -
mean_squared_error: 0.0010 - val_loss: 0.0696 - val_mean_squared_error:
9.8281e-04
Epoch 41/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0699 -
mean_squared_error: 0.0012 - val_loss: 0.0694 - val_mean_squared_error:
9.2146e-04
Epoch 42/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0696 -
mean_squared_error: 0.0010 - val_loss: 0.0693 - val_mean_squared_error:
7.7901e-04
Epoch 43/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0695 -
mean_squared_error: 0.0010 - val_loss: 0.0689 - val_mean_squared_error:
8.0510e-04
Epoch 44/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0693 -
mean_squared_error: 0.0010 - val_loss: 0.0694 - val_mean_squared_error: 0.0012
Epoch 45/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0692 -
mean_squared_error: 0.0010 - val_loss: 0.0691 - val_mean_squared_error: 0.0011
Epoch 46/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0692 -
mean_squared_error: 0.0011 - val_loss: 0.0686 - val_mean_squared_error:
8.3241e-04
Epoch 47/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0689 -
mean_squared_error: 9.9855e-04 - val_loss: 0.0686 - val_mean_squared_error:
8.4821e-04
Epoch 48/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0688 -
mean_squared_error: 0.0010 - val_loss: 0.0686 - val_mean_squared_error:
7.9295e-04
Epoch 49/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0688 -
mean_squared_error: 0.0011 - val_loss: 0.0686 - val_mean_squared_error:
9.1737e-04
Epoch 50/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0686 -
```

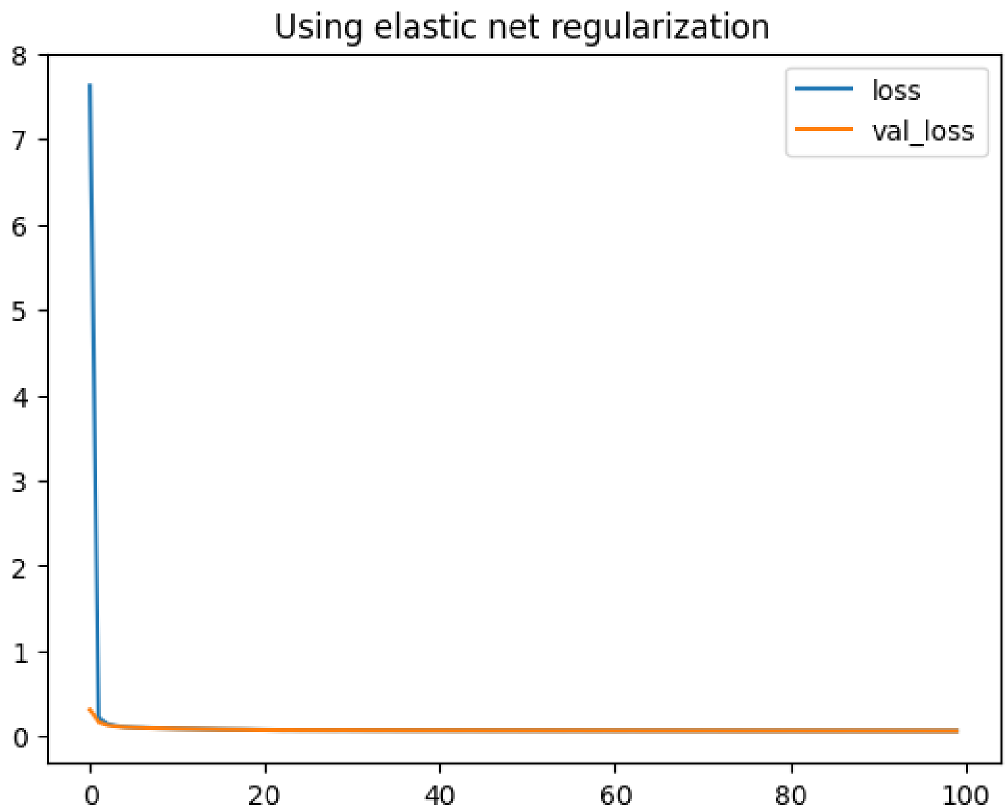
```
mean_squared_error: 0.0010 - val_loss: 0.0683 - val_mean_squared_error:
8.4879e-04
Epoch 51/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0685 -
mean_squared_error: 0.0011 - val_loss: 0.0681 - val_mean_squared_error:
7.9372e-04
Epoch 52/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0684 -
mean_squared_error: 0.0011 - val_loss: 0.0686 - val_mean_squared_error: 0.0013
Epoch 53/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0682 -
mean_squared_error: 0.0010 - val_loss: 0.0680 - val_mean_squared_error:
8.7712e-04
Epoch 54/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0682 -
mean_squared_error: 0.0011 - val_loss: 0.0680 - val_mean_squared_error:
8.9879e-04
Epoch 55/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0681 -
mean_squared_error: 0.0011 - val_loss: 0.0676 - val_mean_squared_error:
7.7041e-04
Epoch 56/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0679 -
mean_squared_error: 0.0010 - val_loss: 0.0680 - val_mean_squared_error: 0.0012
Epoch 57/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0678 -
mean_squared_error: 9.8125e-04 - val_loss: 0.0680 - val_mean_squared_error:
0.0014
Epoch 58/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0678 -
mean_squared_error: 0.0011 - val_loss: 0.0675 - val_mean_squared_error: 0.0012
Epoch 59/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0676 -
mean_squared_error: 9.9584e-04 - val_loss: 0.0675 - val_mean_squared_error:
9.5467e-04
Epoch 60/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0675 -
mean_squared_error: 9.9797e-04 - val_loss: 0.0680 - val_mean_squared_error:
0.0014
Epoch 61/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0675 -
mean_squared_error: 0.0010 - val_loss: 0.0669 - val_mean_squared_error:
8.1982e-04
Epoch 62/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0673 -
mean_squared_error: 9.7734e-04 - val_loss: 0.0671 - val_mean_squared_error:
9.3491e-04
Epoch 63/100
```

```
215/215 [==============================] - 0s 2ms/step - loss: 0.0673 -
mean_squared_error: 0.0011 - val_loss: 0.0675 - val_mean_squared_error: 0.0013
Epoch 64/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0671 -
mean_squared_error: 0.0010 - val_loss: 0.0667 - val_mean_squared_error:
7.9192e-04
Epoch 65/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0671 -
mean_squared_error: 0.0011 - val_loss: 0.0667 - val_mean_squared_error:
8.9222e-04
Epoch 66/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0669 -
mean_squared_error: 0.0010 - val_loss: 0.0668 - val_mean_squared_error:
8.9230e-04
Epoch 67/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0669 -
mean_squared_error: 0.0011 - val_loss: 0.0667 - val_mean_squared_error:
8.1660e-04
Epoch 68/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0668 -
mean_squared_error: 0.0010 - val_loss: 0.0667 - val_mean_squared_error:
8.2893e-04
Epoch 69/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0667 -
mean_squared_error: 9.9408e-04 - val_loss: 0.0664 - val_mean_squared_error:
7.7674e-04
Epoch 70/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0666 -
mean_squared_error: 0.0010 - val_loss: 0.0662 - val_mean_squared_error:
7.6538e-04
Epoch 71/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0666 -
mean_squared_error: 0.0010 - val_loss: 0.0665 - val_mean_squared_error: 0.0011
Epoch 72/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0665 -
mean_squared_error: 0.0010 - val_loss: 0.0666 - val_mean_squared_error: 0.0012
Epoch 73/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0664 -
mean_squared_error: 0.0010 - val_loss: 0.0662 - val_mean_squared_error:
8.6475e-04
Epoch 74/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0665 -
mean_squared_error: 0.0012 - val_loss: 0.0659 - val_mean_squared_error:
8.3473e-04
Epoch 75/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0663 -
mean_squared_error: 0.0010 - val_loss: 0.0659 - val_mean_squared_error:
8.0830e-04
```

```
Epoch 76/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0661 -
mean_squared_error: 9.6055e-04 - val_loss: 0.0657 - val_mean_squared_error:
7.9631e-04
Epoch 77/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0661 -
mean_squared_error: 9.9801e-04 - val_loss: 0.0660 - val_mean_squared_error:
0.0012
Epoch 78/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0660 -
mean_squared_error: 0.0010 - val_loss: 0.0657 - val_mean_squared_error:
8.5133e-04
Epoch 79/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0660 -
mean_squared_error: 0.0011 - val_loss: 0.0656 - val_mean_squared_error:
8.4341e-04
Epoch 80/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0659 -
mean_squared_error: 0.0010 - val_loss: 0.0656 - val_mean_squared_error:
8.3981e-04
Epoch 81/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0659 -
mean_squared_error: 0.0011 - val_loss: 0.0660 - val_mean_squared_error: 0.0012
Epoch 82/100
215/215 [==============================] - 1s 3ms/step - loss: 0.0658 -
mean_squared_error: 0.0011 - val_loss: 0.0656 - val_mean_squared_error: 0.0011
Epoch 83/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0657 -
mean_squared_error: 9.9021e-04 - val_loss: 0.0655 - val_mean_squared_error:
8.7387e-04
Epoch 84/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0657 -
mean_squared_error: 0.0011 - val_loss: 0.0656 - val_mean_squared_error:
9.6323e-04
Epoch 85/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0656 -
mean_squared_error: 0.0010 - val_loss: 0.0653 - val_mean_squared_error:
8.2906e-04
Epoch 86/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0655 -
mean_squared_error: 0.0010 - val_loss: 0.0653 - val_mean_squared_error:
8.8048e-04
Epoch 87/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0656 -
mean_squared_error: 0.0011 - val_loss: 0.0650 - val_mean_squared_error:
8.2338e-04
Epoch 88/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0655 -
```

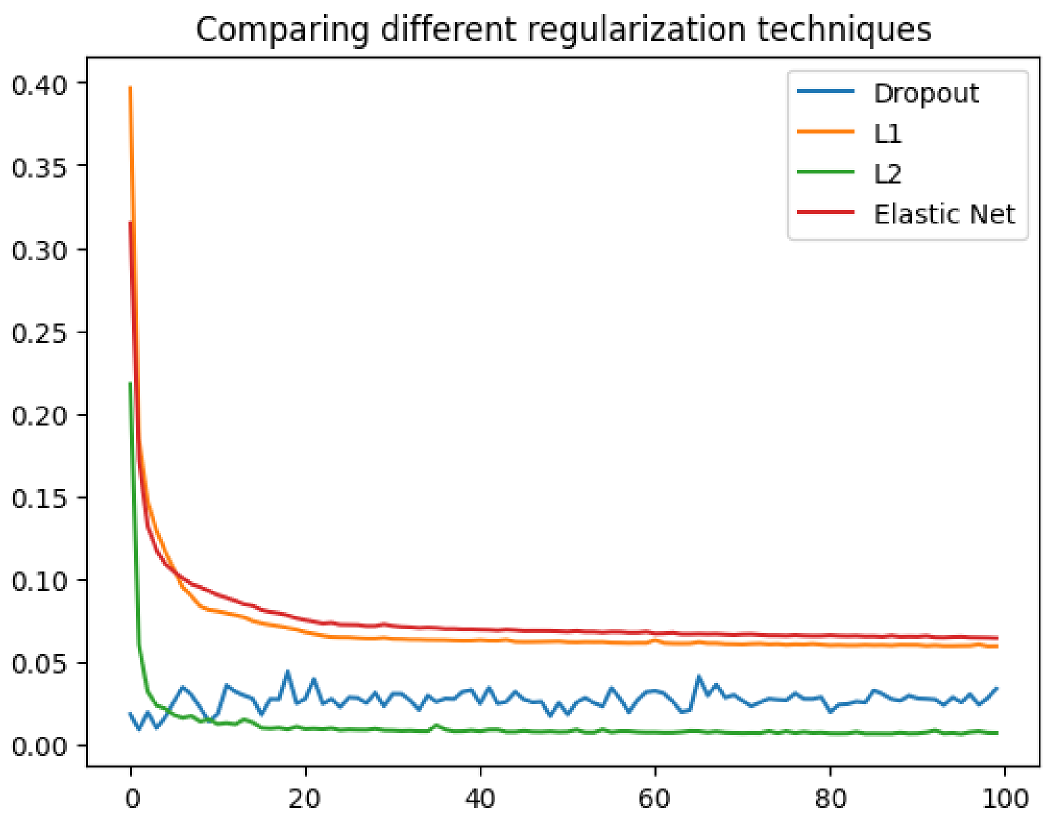
```
mean_squared_error: 0.0011 - val_loss: 0.0657 - val_mean_squared_error: 0.0015
Epoch 89/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0655 -
mean_squared_error: 0.0011 - val_loss: 0.0651 - val_mean_squared_error:
8.7206e-04
Epoch 90/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0653 -
mean_squared_error: 0.0010 - val_loss: 0.0652 - val_mean_squared_error:
9.4304e-04
Epoch 91/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0652 -
mean_squared_error: 0.0010 - val_loss: 0.0651 - val_mean_squared_error: 0.0011
Epoch 92/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0652 -
mean_squared_error: 9.9383e-04 - val_loss: 0.0656 - val_mean_squared_error:
0.0014
Epoch 93/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0651 -
mean_squared_error: 0.0010 - val_loss: 0.0647 - val_mean_squared_error:
8.1710e-04
Epoch 94/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0652 -
mean_squared_error: 0.0011 - val_loss: 0.0646 - val_mean_squared_error:
7.6389e-04
Epoch 95/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0650 -
mean_squared_error: 0.0010 - val_loss: 0.0649 - val_mean_squared_error:
9.3929e-04
Epoch 96/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0650 -
mean_squared_error: 0.0010 - val_loss: 0.0651 - val_mean_squared_error: 0.0011
Epoch 97/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0649 -
mean_squared_error: 9.9785e-04 - val_loss: 0.0646 - val_mean_squared_error:
8.8434e-04
Epoch 98/100
215/215 [==============================] - 1s 2ms/step - loss: 0.0649 -
mean_squared_error: 0.0011 - val_loss: 0.0645 - val_mean_squared_error:
8.0498e-04
Epoch 99/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0648 -
mean_squared_error: 9.8291e-04 - val_loss: 0.0644 - val_mean_squared_error:
8.4214e-04
Epoch 100/100
215/215 [==============================] - 0s 2ms/step - loss: 0.0648 -
mean_squared_error: 0.0010 - val_loss: 0.0642 - val_mean_squared_error:
7.6755e-04
```

[63]:
```
plt.plot(elastic_history.history['loss'], label='loss')
plt.plot(elastic_history.history['val_loss'], label='val_loss')
plt.legend()
plt.title('Using elastic net regularization')
plt.show()
```



1.0.7 Comparing Regularization Techniques

[64]:
```
plt.plot(history.history['val_loss'], label='Dropout')
plt.plot(l1_history.history['val_loss'], label='L1')
plt.plot(l2_history.history['val_loss'], label='L2')
plt.plot(elastic_history.history['val_loss'], label='Elastic Net')
plt.legend()
plt.title('Comparing different regularization techniques')
plt.show()
```



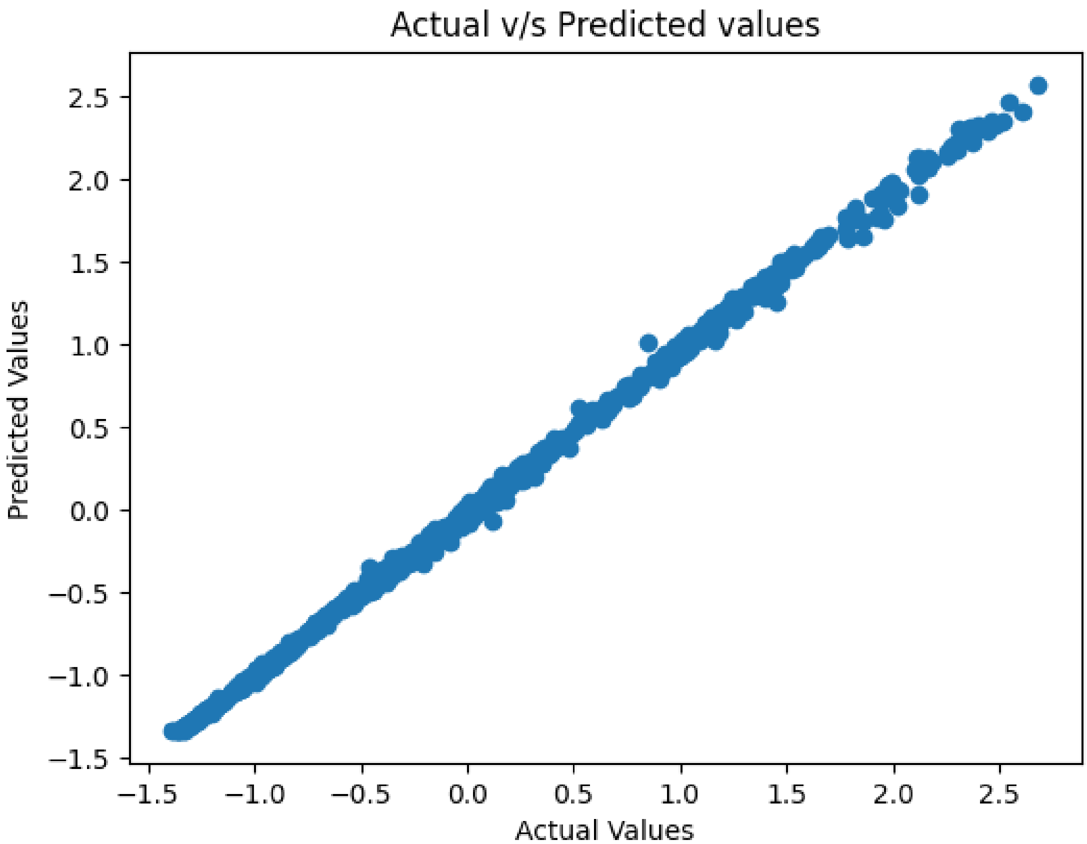
L2 regularization appears to obtain the best results. This makes sense as with L2 regularization, the network becomes less sensitive to small changes in the input data which is usually the case with stock markets.

1.0.8 Looking at the predictions

We will use the model created with L2 regularization.

[74]:
```
# Predicting the values
y_pred = l2_model.predict(X_test)

# Plotting the predictions
plt.scatter(y_test, y_pred)
plt.title("Actual v/s Predicted values")
plt.xlabel("Actual Values")
plt.ylabel("Predicted Values")
plt.show()
```

```
30/30 [==============================] - 0s 2ms/step
```



Wonderful! We get a linear curve which signifies that the predictions are very close to the actual values.

2 End