MLP model_True

November 24, 2024

[7]:
```
# first neural network with keras tutorial
import tensorflow as tf
from tensorflow import keras
from numpy import loadtxt
from keras.models import Sequential
from keras.layers import Dense
#from keras.wrappers.scikit_learn import KerasRegressor
from scikeras.wrappers import KerasClassifier, KerasRegressor
from sklearn.model_selection import cross_val_score
from sklearn.datasets import make_regression
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_absolute_error
from numpy import asarray
from numpy import unique
from numpy import argmax
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.model_selection import train_test_split
import numpy as np
from tensorflow.keras.utils import plot_model
```

[9]:
```
%pip install tensorflow
```

```
Requirement already satisfied: tensorflow in h:\anaconda\lib\site-packages
(2.18.0)
Requirement already satisfied: tensorflow-intel==2.18.0 in h:\anaconda\lib\site-
packages (from tensorflow) (2.18.0)
Requirement already satisfied: absl-py>=1.0.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (2.1.0)
Requirement already satisfied: astunparse>=1.6.0 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (24.3.25)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in
h:\anaconda\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow)
(0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (0.2.0)
```

```
Requirement already satisfied: libclang>=13.0.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (3.4.0)
Requirement already satisfied: packaging in h:\anaconda\lib\site-packages (from
tensorflow-intel==2.18.0->tensorflow) (24.1)
Requirement already satisfied:
protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<6.0.0dev,>=3.20.3
in h:\anaconda\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow)
(4.25.3)
Requirement already satisfied: requests<3,>=2.21.0 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (2.32.3)
Requirement already satisfied: setuptools in h:\anaconda\lib\site-packages (from
tensorflow-intel==2.18.0->tensorflow) (75.1.0)
Requirement already satisfied: six>=1.12.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (2.5.0)
Requirement already satisfied: typing-extensions>=3.6.6 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (4.11.0)
Requirement already satisfied: wrapt>=1.11.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (1.14.1)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (1.68.0)
Requirement already satisfied: tensorboard<2.19,>=2.18 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (2.18.0)
Requirement already satisfied: keras>=3.5.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (3.6.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (1.26.4)
Requirement already satisfied: h5py>=3.11.0 in h:\anaconda\lib\site-packages
(from tensorflow-intel==2.18.0->tensorflow) (3.11.0)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in h:\anaconda\lib\site-
packages (from tensorflow-intel==2.18.0->tensorflow) (0.4.1)
Requirement already satisfied: wheel<1.0,>=0.23.0 in h:\anaconda\lib\site-
packages (from astunparse>=1.6.0->tensorflow-intel==2.18.0->tensorflow) (0.44.0)
Requirement already satisfied: rich in h:\anaconda\lib\site-packages (from
keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (13.7.1)
Requirement already satisfied: namex in h:\anaconda\lib\site-packages (from
keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (0.0.8)
Requirement already satisfied: optree in h:\anaconda\lib\site-packages (from
keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (0.13.1)
Requirement already satisfied: charset-normalizer<4,>=2 in h:\anaconda\lib\site-
packages (from requests<3,>=2.21.0->tensorflow-intel==2.18.0->tensorflow)
(3.3.2)
Requirement already satisfied: idna<4,>=2.5 in h:\anaconda\lib\site-packages
(from requests<3,>=2.21.0->tensorflow-intel==2.18.0->tensorflow) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in h:\anaconda\lib\site-
```

```
packages (from requests<3,>=2.21.0->tensorflow-intel==2.18.0->tensorflow)
(2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in h:\anaconda\lib\site-
packages (from requests<3,>=2.21.0->tensorflow-intel==2.18.0->tensorflow)
(2024.8.30)
Requirement already satisfied: markdown>=2.6.8 in h:\anaconda\lib\site-packages
(from tensorboard<2.19,>=2.18->tensorflow-intel==2.18.0->tensorflow) (3.4.1)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in
h:\anaconda\lib\site-packages (from tensorboard<2.19,>=2.18->tensorflow-
intel==2.18.0->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in h:\anaconda\lib\site-packages
(from tensorboard<2.19,>=2.18->tensorflow-intel==2.18.0->tensorflow) (3.0.3)
Requirement already satisfied: MarkupSafe>=2.1.1 in h:\anaconda\lib\site-
packages (from werkzeug>=1.0.1->tensorboard<2.19,>=2.18->tensorflow-
intel==2.18.0->tensorflow) (2.1.3)
Requirement already satisfied: markdown-it-py>=2.2.0 in h:\anaconda\lib\site-
packages (from rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (2.2.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in h:\anaconda\lib\site-
packages (from rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow)
(2.15.1)
Requirement already satisfied: mdurl~=0.1 in h:\anaconda\lib\site-packages (from
markdown-it-py>=2.2.0->rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow)
(0.1.0)
Note: you may need to restart the kernel to use updated packages.
```

[13]:
```
# load the dataset
dataset = loadtxt('Data/datas.csv', delimiter=',')
```

[15]:
```
# #ESSAI 3  -----OK
X = dataset[:,0:7]
y = dataset[:,7]
scalarX, scalarY = MinMaxScaler(feature_range=(0,0.75)),␣
 ↪MinMaxScaler(feature_range=(0,0.75))
scalarX.fit(X)
scalarY.fit(y.reshape(94,1))
X = scalarX.transform(X)
y=np.array(y).reshape(94,1)
y = scalarY.transform(y)
```

[17]:
```
print(y)
```

```
[[0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
```

```
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
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[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[5.71983935e-04]
[2.18923901e-03]
[4.74422103e-03]
[8.22762667e-03]
[1.23189629e-02]
[1.77387289e-02]
[2.42075523e-02]
[3.08176139e-02]
[3.95917972e-02]
[4.92520136e-02]
[5.97893942e-02]
[7.09169107e-02]
[8.20202916e-02]
```

```
 [9.18582411e-02]
 [1.02595174e-01]
 [1.13708303e-01]
 [1.27787857e-01]
 [1.44147250e-01]
 [1.61351537e-01]
 [1.82024197e-01]
 [2.03626676e-01]
 [2.23773302e-01]
 [2.42121629e-01]
 [2.61462524e-01]
 [2.83741332e-01]
 [3.08130991e-01]
 [3.32849942e-01]
 [3.57598221e-01]
 [3.81505202e-01]
 [4.10808924e-01]
 [4.36042928e-01]
 [4.65689622e-01]
 [4.94960919e-01]
 [5.28935958e-01]
 [5.35587435e-01]
 [5.49707126e-01]
 [5.67077886e-01]
 [5.83964416e-01]
 [5.92958436e-01]
 [6.03276245e-01]
 [6.13848251e-01]
 [6.24868091e-01]
 [6.42382335e-01]
 [6.61105999e-01]
 [6.74930273e-01]
 [6.82905842e-01]
 [6.94466083e-01]
 [7.08957685e-01]
 [7.24161220e-01]
 [7.37046700e-01]
 [7.50000000e-01]
 [7.50000000e-01]]
```

[19]:
```
print(X)
```

```
[[0.         0.         0.         0.66412214 0.26923077 0.
  0.        ]
 [0.00806452 0.         0.         0.68702288 0.30769231 0.
  0.        ]
 [0.01612903 0.05769256 0.         0.68702288 0.38461538 0.06428571
  0.03191489]
```

```
[0.02419355 0.05769256 0.         0.68702288 0.48076923 0.17142857
 0.07978723]
[0.03225806 0.11538512 0.09036145 0.37786261 0.53846154 0.36428571
 0.28723404]
[0.04032258 0.11538512 0.37951807 0.2977099  0.48076923 0.42857143
 0.35106383]
[0.0483871  0.11538512 0.21686747 0.31488549 0.19230769 0.12857143
 0.11170213]
[0.05645161 0.17307702 0.09036145 0.40648856 0.19230769 0.
 0.03191489]
[0.06451613 0.17307702 0.04518072 0.38358776 0.32692308 0.15
 0.12765957]
[0.07258065 0.23076958 0.         0.5381679  0.42307692 0.3
 0.2393617 ]
[0.08064516 0.23076958 0.         0.48091599 0.5        0.42857143
 0.35106383]
[0.08870968 0.23076958 0.         0.41793893 0.5        0.49285714
 0.41489362]
[0.09677419 0.28846149 0.02710843 0.27480916 0.51923077 0.49285714
 0.41489362]
[0.10483871 0.28846149 0.02710843 0.1316794  0.38461538 0.51428571
 0.44680851]
[0.11290323 0.28846149 0.01807229 0.2977099  0.36538462 0.47142857
 0.39893617]
[0.12096774 0.34615405 0.01807229 0.45801525 0.40384615 0.38571429
 0.31914894]
[0.12903226 0.34615405 0.02710843 0.35496181 0.48076923 0.36428571
 0.28723404]
[0.13709677 0.4038466  0.09036145 0.2977099  0.51923077 0.47142857
 0.39893617]
[0.14516129 0.4038466  0.07228916 0.31488549 0.46153846 0.40714286
 0.33510638]
[0.15322581 0.4038466  0.02710843 0.33778623 0.5        0.40714286
 0.33510638]
[0.16129032 0.46153851 0.09036145 0.30916027 0.46153846 0.40714286
 0.33510638]
[0.16935484 0.46153851 0.11746988 0.36068702 0.19230769 0.08571429
 0.07978723]
[0.17741935 0.46153851 0.12650602 0.         0.         0.23571429
 0.19148936]
[0.18548387 0.46153851 0.01807229 0.14885495 0.03846154 0.23571429
 0.19148936]
[0.19354839 0.51923107 0.         0.1889313  0.11538462 0.3
 0.2393617 ]
[0.2016129  0.51923107 0.         0.22900763 0.17307692 0.34285714
 0.2712766 ]
[0.20967742 0.51923107 0.02710843 0.05725191 0.19230769 0.40714286
 0.33510638]
```

```
[0.21774194 0.57692298 0.00903614 0.33206107 0.30769231 0.42857143
 0.35106383]
[0.22580645 0.57692298 0.         0.54961833 0.38461538 0.34285714
 0.2712766 ]
[0.23387097 0.57692298 0.04518072 0.14312977 0.32692308 0.49285714
 0.41489362]
[0.24193548 0.57692298 0.         0.5610687  0.40384615 0.36428571
 0.28723404]
[0.25       0.63461553 0.         0.42366409 0.30769231 0.38571429
 0.31914894]
[0.25806452 0.63461553 0.         0.72137405 0.30769231 0.08571429
 0.07978723]
[0.26612903 0.63461553 0.         0.67557251 0.30769231 0.17142857
 0.14361702]
[0.27419355 0.63461553 0.04518072 0.37213739 0.21153846 0.19285714
 0.15957447]
[0.28225806 0.63461553 0.         0.64694656 0.26923077 0.17142857
 0.14361702]
[0.29032258 0.69230809 0.         0.72137405 0.34615385 0.12857143
 0.11170213]
[0.2983871  0.69230809 0.         0.53244274 0.30769231 0.32142857
 0.25531915]
[0.30645161 0.69230809 0.12650602 0.30916027 0.42307692 0.47142857
 0.39893617]
[0.31451613 0.69230809 0.         0.68129767 0.42307692 0.27857143
 0.22340426]
[0.32258065 0.69230809 0.03614458 0.2977099  0.36538462 0.42857143
 0.35106383]
[0.33064516 0.69230809 0.         0.72709926 0.38461538 0.17142857
 0.14361702]
[0.33870968 0.69230809 0.         0.72709926 0.44230769 0.21428571
 0.17553191]
[0.34677419 0.75       0.03614458 0.45229004 0.44230769 0.27857143
 0.22340426]
[0.35483871 0.75       0.         0.75       0.46153846 0.15
 0.12765957]
[0.36290323 0.75       0.         0.59541981 0.46153846 0.38571429
 0.31914894]
[0.37096774 0.75       0.75       0.22900763 0.36538462 0.47142857
 0.39893617]
[0.37903226 0.75       0.         0.64694656 0.32692308 0.21428571
 0.17553191]
[0.38709677 0.75       0.         0.57824428 0.36538462 0.32142857
 0.25531915]
[0.39516129 0.75       0.02710843 0.30916027 0.30769231 0.34285714
 0.2712766 ]
[0.40322581 0.75       0.         0.6698473  0.30769231 0.17142857
 0.14361702]
```

```
[0.41129032 0.75       0.         0.57824428 0.38461538 0.34285714
 0.2712766 ]
[0.41935484 0.75       0.         0.70992362 0.42307692 0.19285714
 0.15957447]
[0.42741935 0.75       0.         0.68129767 0.40384615 0.21428571
 0.17553191]
[0.43548387 0.75       0.         0.68702288 0.48076923 0.25714286
 0.20744681]
[0.44354839 0.75       0.         0.65839693 0.57692308 0.36428571
 0.28723404]
[0.4516129  0.75       0.         0.42366409 0.51923077 0.55714286
 0.49468085]
[0.45967742 0.75       0.11746988 0.34351144 0.40384615 0.34285714
 0.2712766 ]
[0.46774194 0.75       0.         0.49236642 0.51923077 0.49285714
 0.41489362]
[0.47580645 0.75       0.         0.45229004 0.57692308 0.57857143
 0.52659574]
[0.48387097 0.75       0.         0.38358776 0.53846154 0.6
 0.54255319]
[0.49193548 0.75       0.         0.40648856 0.36538462 0.40714286
 0.33510638]
[0.5        0.69230809 0.         0.5381679  0.38461538 0.32142857
 0.25531915]
[0.50806452 0.69230809 0.         0.44083967 0.40384615 0.42857143
 0.35106383]
[0.51612903 0.69230809 0.         0.51526716 0.63461538 0.57857143
 0.52659574]
[0.52419355 0.69230809 0.         0.65267171 0.75       0.49285714
 0.41489362]
[0.53225806 0.69230809 0.         0.44656488 0.73076923 0.72857143
 0.71808511]
[0.54032258 0.69230809 0.         0.41793893 0.63461538 0.66428571
 0.62234043]
[0.5483871  0.69230809 0.29819277 0.33778623 0.55769231 0.49285714
 0.41489362]
[0.55645161 0.63461553 0.         0.58969465 0.53846154 0.40714286
 0.33510638]
[0.56451613 0.63461553 0.         0.49236642 0.57692308 0.53571429
 0.46276596]
[0.57258065 0.63461553 0.22590361 0.21183204 0.5        0.57857143
 0.52659574]
[0.58064516 0.63461553 0.0813253  0.26335879 0.46153846 0.49285714
 0.41489362]
[0.58870968 0.63461553 0.         0.60687023 0.55769231 0.40714286
 0.33510638]
[0.59677419 0.57692298 0.07228916 0.40648856 0.61538462 0.45
 0.38297872]
```

```
[0.60483871 0.57692298 0.         0.50954195 0.57692308 0.53571429
 0.46276596]
[0.61290323 0.57692298 0.11746988 0.26335879 0.61538462 0.64285714
 0.60638298]
[0.62096774 0.57692298 0.22590361 0.2977099  0.63461538 0.62142857
 0.57446809]
[0.62903226 0.51923107 0.         0.38358776 0.69230769 0.75
 0.75      ]
[0.63709677 0.51923107 0.5873494  0.31488549 0.63461538 0.6
 0.54255319]
[0.64516129 0.51923107 0.         0.38358776 0.57692308 0.64285714
 0.60638298]
[0.65322581 0.51923107 0.         0.40648856 0.59615385 0.64285714
 0.60638298]
[0.66129032 0.46153851 0.         0.38931298 0.59615385 0.66428571
 0.62234043]
[0.66935484 0.46153851 0.         0.52099237 0.57692308 0.53571429
 0.46276596]
[0.67741935 0.46153851 0.         0.52671753 0.55769231 0.51428571
 0.44680851]
[0.68548387 0.4038466  0.         0.58396944 0.57692308 0.47142857
 0.39893617]
[0.69354839 0.4038466  0.         0.52671753 0.63461538 0.57857143
 0.52659574]
[0.7016129  0.4038466  0.         0.52099237 0.67307692 0.62142857
 0.57446809]
[0.70967742 0.34615405 0.         0.41793893 0.59615385 0.64285714
 0.60638298]
[0.71774194 0.34615405 0.         0.54961833 0.51923077 0.45
 0.38297872]
[0.72580645 0.34615405 0.         0.54389311 0.51923077 0.45
 0.38297872]
[0.73387097 0.28846149 0.04518072 0.37786261 0.5        0.38571429
 0.31914894]
[0.74193548 0.28846149 0.         0.60687023 0.53846154 0.38571429
 0.31914894]
[0.75       0.28846149 0.         0.57824428 0.65384615 0.51428571
 0.44680851]]
```

[21]:
```
# define the keras model
model = Sequential()
model.add(Dense(20, input_dim=7, kernel_initializer='normal',␣
 ↪activation='relu')) #kernel_initializer='normal'
model.add(Dense(1, kernel_initializer='normal', activation='linear')) #linear
print(model.summary())
```

```
H:\Anaconda\Lib\site-packages\keras\src\layers\core\dense.py:87: UserWarning: Do
not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential
```

```
models, prefer using an `Input(shape)` object as the first layer in the model
instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

Model: "sequential"

Layer (type)	Output Shape	Param #
dense (Dense)	(None, 20)	160
dense_1 (Dense)	(None, 1)	21

Total params: 181 (724.00 B)

Trainable params: 181 (724.00 B)

Non-trainable params: 0 (0.00 B)

```
None
```

[23]:
```
model.compile(optimizer='adam', loss='mean_absolute_error')
```

[25]:
```
# fit the keras model on the dataset
history = model.fit(X, y, epochs=60, batch_size=4, verbose=2,␣
 ↪validation_split=0.20)
```

```
Epoch 1/60
19/19 - 1s - 29ms/step - loss: 0.0750 - val_loss: 0.6319
Epoch 2/60
19/19 - 0s - 2ms/step - loss: 0.0740 - val_loss: 0.6285
Epoch 3/60
19/19 - 0s - 2ms/step - loss: 0.0736 - val_loss: 0.6257
Epoch 4/60
19/19 - 0s - 2ms/step - loss: 0.0740 - val_loss: 0.6206
Epoch 5/60
19/19 - 0s - 2ms/step - loss: 0.0726 - val_loss: 0.6174
Epoch 6/60
19/19 - 0s - 2ms/step - loss: 0.0722 - val_loss: 0.6160
Epoch 7/60
19/19 - 0s - 2ms/step - loss: 0.0715 - val_loss: 0.6080
Epoch 8/60
19/19 - 0s - 2ms/step - loss: 0.0721 - val_loss: 0.5965
Epoch 9/60
19/19 - 0s - 2ms/step - loss: 0.0706 - val_loss: 0.6050
```

```
Epoch 10/60
19/19 - 0s - 2ms/step - loss: 0.0699 - val_loss: 0.5959
Epoch 11/60
19/19 - 0s - 2ms/step - loss: 0.0696 - val_loss: 0.5854
Epoch 12/60
19/19 - 0s - 2ms/step - loss: 0.0688 - val_loss: 0.5888
Epoch 13/60
19/19 - 0s - 2ms/step - loss: 0.0680 - val_loss: 0.5752
Epoch 14/60
19/19 - 0s - 2ms/step - loss: 0.0682 - val_loss: 0.5806
Epoch 15/60
19/19 - 0s - 2ms/step - loss: 0.0666 - val_loss: 0.5646
Epoch 16/60
19/19 - 0s - 2ms/step - loss: 0.0657 - val_loss: 0.5710
Epoch 17/60
19/19 - 0s - 2ms/step - loss: 0.0645 - val_loss: 0.5574
Epoch 18/60
19/19 - 0s - 2ms/step - loss: 0.0638 - val_loss: 0.5456
Epoch 19/60
19/19 - 0s - 2ms/step - loss: 0.0618 - val_loss: 0.5504
Epoch 20/60
19/19 - 0s - 2ms/step - loss: 0.0612 - val_loss: 0.5369
Epoch 21/60
19/19 - 0s - 2ms/step - loss: 0.0597 - val_loss: 0.5291
Epoch 22/60
19/19 - 0s - 2ms/step - loss: 0.0589 - val_loss: 0.5108
Epoch 23/60
19/19 - 0s - 2ms/step - loss: 0.0565 - val_loss: 0.5084
Epoch 24/60
19/19 - 0s - 2ms/step - loss: 0.0549 - val_loss: 0.4919
Epoch 25/60
19/19 - 0s - 2ms/step - loss: 0.0539 - val_loss: 0.4819
Epoch 26/60
19/19 - 0s - 2ms/step - loss: 0.0521 - val_loss: 0.4788
Epoch 27/60
19/19 - 0s - 2ms/step - loss: 0.0511 - val_loss: 0.4542
Epoch 28/60
19/19 - 0s - 2ms/step - loss: 0.0507 - val_loss: 0.4576
Epoch 29/60
19/19 - 0s - 2ms/step - loss: 0.0468 - val_loss: 0.4364
Epoch 30/60
19/19 - 0s - 2ms/step - loss: 0.0461 - val_loss: 0.4403
Epoch 31/60
19/19 - 0s - 2ms/step - loss: 0.0439 - val_loss: 0.4134
Epoch 32/60
19/19 - 0s - 2ms/step - loss: 0.0427 - val_loss: 0.4165
Epoch 33/60
19/19 - 0s - 2ms/step - loss: 0.0416 - val_loss: 0.3886
```

```
Epoch 34/60
19/19 - 0s - 2ms/step - loss: 0.0412 - val_loss: 0.3935
Epoch 35/60
19/19 - 0s - 2ms/step - loss: 0.0392 - val_loss: 0.3775
Epoch 36/60
19/19 - 0s - 2ms/step - loss: 0.0390 - val_loss: 0.3671
Epoch 37/60
19/19 - 0s - 2ms/step - loss: 0.0375 - val_loss: 0.3621
Epoch 38/60
19/19 - 0s - 2ms/step - loss: 0.0381 - val_loss: 0.3539
Epoch 39/60
19/19 - 0s - 2ms/step - loss: 0.0383 - val_loss: 0.3401
Epoch 40/60
19/19 - 0s - 2ms/step - loss: 0.0350 - val_loss: 0.3389
Epoch 41/60
19/19 - 0s - 2ms/step - loss: 0.0338 - val_loss: 0.3171
Epoch 42/60
19/19 - 0s - 2ms/step - loss: 0.0334 - val_loss: 0.3120
Epoch 43/60
19/19 - 0s - 2ms/step - loss: 0.0329 - val_loss: 0.3156
Epoch 44/60
19/19 - 0s - 2ms/step - loss: 0.0314 - val_loss: 0.3032
Epoch 45/60
19/19 - 0s - 2ms/step - loss: 0.0318 - val_loss: 0.3040
Epoch 46/60
19/19 - 0s - 2ms/step - loss: 0.0312 - val_loss: 0.3043
Epoch 47/60
19/19 - 0s - 2ms/step - loss: 0.0304 - val_loss: 0.2765
Epoch 48/60
19/19 - 0s - 2ms/step - loss: 0.0292 - val_loss: 0.2841
Epoch 49/60
19/19 - 0s - 2ms/step - loss: 0.0291 - val_loss: 0.2818
Epoch 50/60
19/19 - 0s - 2ms/step - loss: 0.0278 - val_loss: 0.2577
Epoch 51/60
19/19 - 0s - 2ms/step - loss: 0.0293 - val_loss: 0.2688
Epoch 52/60
19/19 - 0s - 2ms/step - loss: 0.0283 - val_loss: 0.2481
Epoch 53/60
19/19 - 0s - 2ms/step - loss: 0.0278 - val_loss: 0.2487
Epoch 54/60
19/19 - 0s - 2ms/step - loss: 0.0262 - val_loss: 0.2438
Epoch 55/60
19/19 - 0s - 2ms/step - loss: 0.0259 - val_loss: 0.2516
Epoch 56/60
19/19 - 0s - 2ms/step - loss: 0.0260 - val_loss: 0.2451
Epoch 57/60
19/19 - 0s - 2ms/step - loss: 0.0262 - val_loss: 0.2422
```

```
Epoch 58/60
19/19 - 0s - 2ms/step - loss: 0.0263 - val_loss: 0.2538
Epoch 59/60
19/19 - 0s - 2ms/step - loss: 0.0247 - val_loss: 0.2338
Epoch 60/60
19/19 - 0s - 2ms/step - loss: 0.0235 - val_loss: 0.2306
```

[26]:
```
# evaluate on test set
yhat = model.predict(X)
error = mean_absolute_error(y, yhat)
print('MAE: %.5f' % error)
```

```
3/3             0s 9ms/step
MAE: 0.06605
```

[27]:
```
print(yhat)
```

```
[[ 0.00336682]
 [ 0.00553632]
 [ 0.00437989]
 [ 0.00719467]
 [ 0.00677666]
 [ 0.00600518]
 [ 0.00337909]
 [ 0.00177365]
 [ 0.00562955]
 [ 0.00242475]
 [ 0.00550492]
 [ 0.0074371 ]
 [ 0.00588476]
 [ 0.00608368]
 [ 0.00592454]
 [ 0.00229497]
 [ 0.00639455]
 [ 0.00421714]
 [ 0.00470172]
 [ 0.00670858]
 [ 0.00311753]
 [ 0.0005581 ]
 [ 0.00085422]
 [ 0.00151872]
 [-0.00100603]
 [ 0.00116866]
 [ 0.00454571]
 [ 0.00090294]
 [ 0.00240229]
 [ 0.00644707]
 [ 0.00578509]
 [ 0.00178419]
```

```
[ 0.00215453]
[ 0.0037384 ]
[ 0.00619764]
[ 0.00644486]
[ 0.00421463]
[ 0.00577594]
[ 0.02817386]
[ 0.01015864]
[ 0.03282613]
[ 0.01273959]
[ 0.01527191]
[ 0.02543732]
[ 0.01407364]
[ 0.04592153]
[ 0.0211373 ]
[ 0.01682431]
[ 0.03923267]
[ 0.05985572]
[ 0.02127307]
[ 0.06568245]
[ 0.05037941]
[ 0.05832531]
[ 0.08515538]
[ 0.12661268]
[ 0.17122307]
[ 0.12150034]
[ 0.16806588]
[ 0.20408691]
[ 0.21192887]
[ 0.15366577]
[ 0.15041111]
[ 0.18395275]
[ 0.25315166]
[ 0.25664726]
[ 0.31641823]
[ 0.29492015]
[ 0.24029624]
[ 0.24477606]
[ 0.2859967 ]
[ 0.29022643]
[ 0.28403682]
[ 0.27379665]
[ 0.32098332]
[ 0.32762265]
[ 0.37167567]
[ 0.36453065]
[ 0.4276427 ]
[ 0.34533477]
```

```
 [ 0.39946467]
 [ 0.40788817]
 [ 0.42655697]
 [ 0.39730367]
 [ 0.39629525]
 [ 0.4018125 ]
 [ 0.44173622]
 [ 0.46309897]
 [ 0.47088993]
 [ 0.4202584 ]
 [ 0.42682606]
 [ 0.4342584 ]
 [ 0.43516994]
 [ 0.48657355]]
```

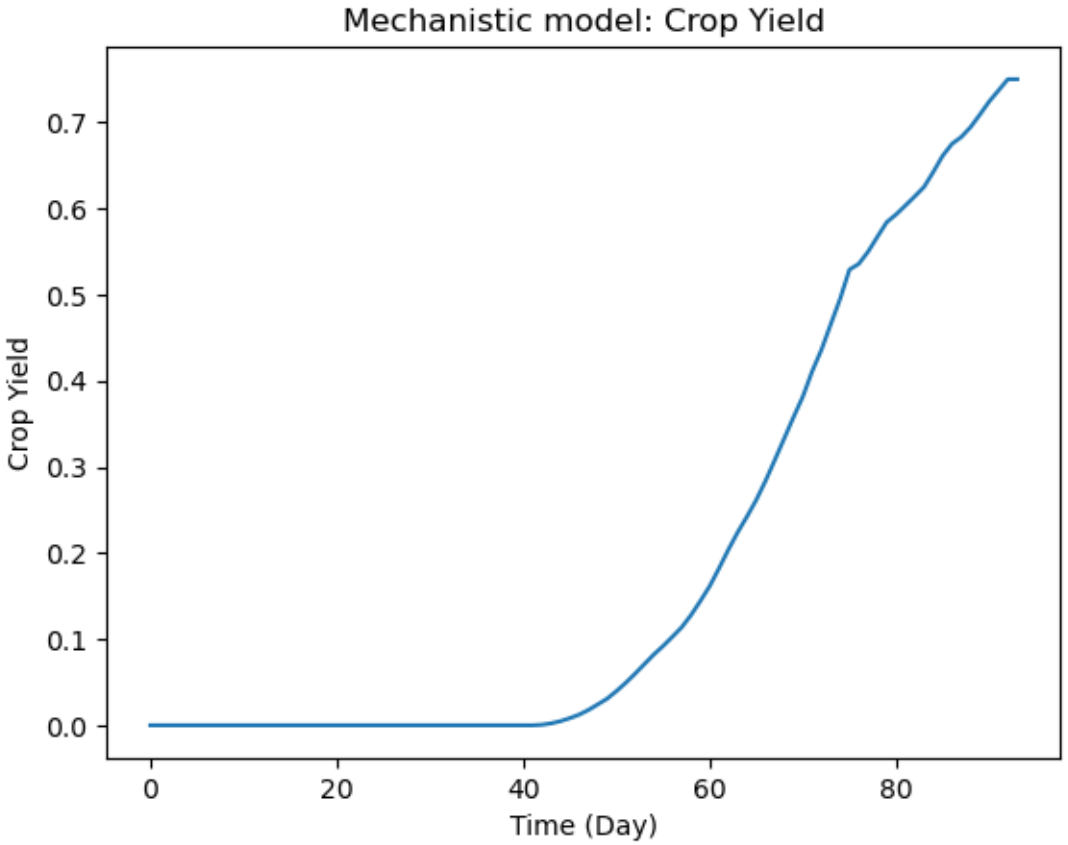
[31]:
```python
print(y)
```

```
[[0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
 [0.00000000e+00]
```

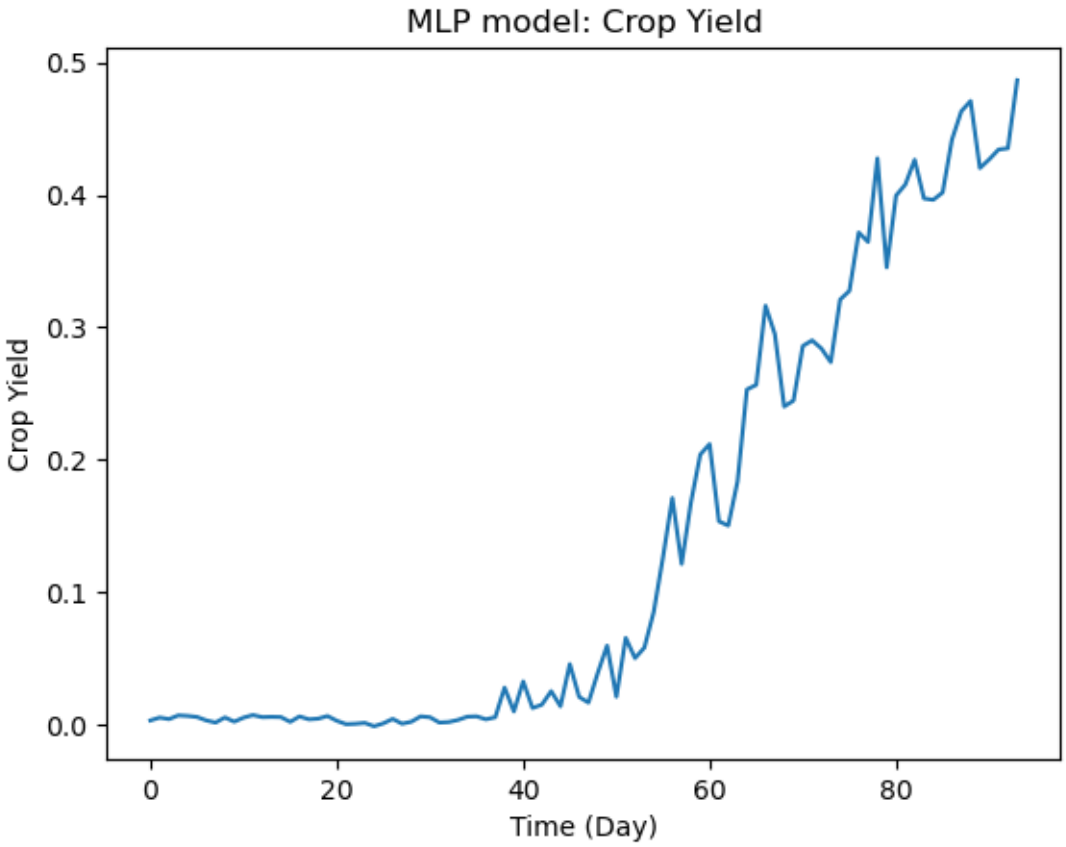
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[0.00000000e+00]
[5.71983935e-04]
[2.18923901e-03]
[4.74422103e-03]
[8.22762667e-03]
[1.23189629e-02]
[1.77387289e-02]
[2.42075523e-02]
[3.08176139e-02]
[3.95917972e-02]
[4.92520136e-02]
[5.97893942e-02]
[7.09169107e-02]
[8.20202916e-02]
[9.18582411e-02]
[1.02595174e-01]
[1.13708303e-01]
[1.27787857e-01]
[1.44147250e-01]
[1.61351537e-01]
[1.82024197e-01]
[2.03626676e-01]
[2.23773302e-01]
[2.42121629e-01]
[2.61462524e-01]
[2.83741332e-01]
[3.08130991e-01]
[3.32849942e-01]
[3.57598221e-01]
[3.81505202e-01]
[4.10808924e-01]
[4.36042928e-01]
[4.65689622e-01]
[4.94960919e-01]
[5.28935958e-01]
[5.35587435e-01]
[5.49707126e-01]
[5.67077886e-01]

```
[5.83964416e-01]
[5.92958436e-01]
[6.03276245e-01]
[6.13848251e-01]
[6.24868091e-01]
[6.42382335e-01]
[6.61105999e-01]
[6.74930273e-01]
[6.82905842e-01]
[6.94466083e-01]
[7.08957685e-01]
[7.24161220e-01]
[7.37046700e-01]
[7.50000000e-01]
[7.50000000e-01]]
```

[33]:
```
plt.plot(y)
plt.xlabel('Time (Day)')
plt.ylabel('Crop Yield')
plt.title('Mechanistic model: Crop Yield')
plt.show()
```



[35]:
```
plt.plot(yhat)
plt.xlabel('Time (Day)')
plt.ylabel('Crop Yield')
plt.title('MLP model: Crop Yield')
plt.show()
```



[ ]:

[ ]: