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ME 249 Project 3 Report

For Project 3, I worked on all of the tasks by myself. This project looked at the performance of the solar panel designs connected 72 cells in series (Task 1), and 4 cells in series and/or parallel (Task 2).

Task 1

In task 1.1, I was given operating and performance parameter data for the solar panel design as DS3.1.1Lowflux data array. Each of the three input parameters—T_{air}, I_D, R_L—were standardized by subtracting the mean and dividing by the standard deviation. Modifying the given P3pcaExample code, I determined the eigenvalues and eigenvectors of the input variable array, summarized in table 1 below. The scatter plots of the standardized data and PCA data are included in Figure 1 as well. Based on the scatter plots as well as the eigenvectors and eigenvalues, most important value is I_D, and then R_L. It seems that T_{air} does not have as much of an importance.

Table 1. Eigenvalues and Eigenvectors of the input variable matrix [T_{air}, I_D, R_L].

Eigenvalues	[1.02857143 1.02857143 1.02857143]
Eigenvectors	[[1.00000000e+00 -3.60481637e-02 -1.37997442e-18] [0.00000000e+00 -9.52653369e-01 -3.02110398e-01] [0.00000000e+00 -3.01914043e-01 9.53272945e-01]]

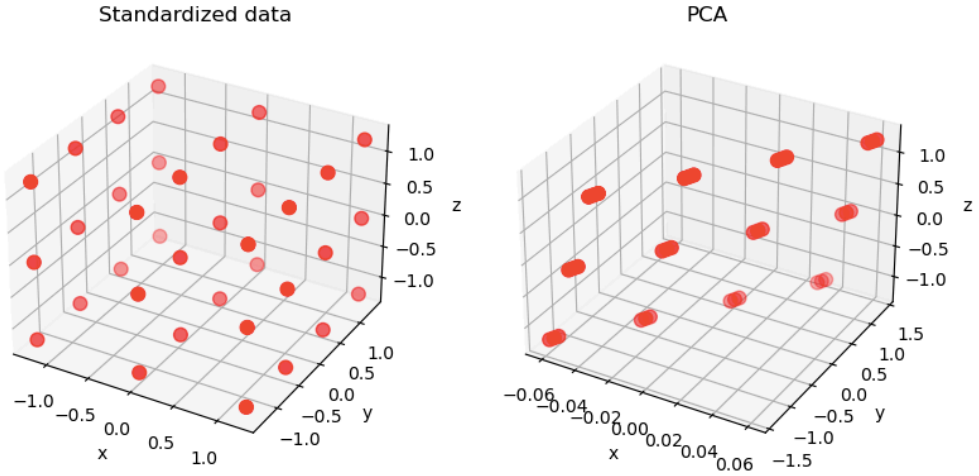

Figure 1. Scatter plots of the standardized data (left) and PCA data (right). X represents T_{air}, y is I_D, and z is R_L. Based on the scatter plots as well as the eigenvectors and eigenvalues, most important value is I_D and then R_L. It seems that T_{air} does not have as much of an importance.

In task 1.2, I was given CodeP3.1.2 from class that contains the basic Keras neural network model structure. First, I normalized the DS3.1.1Lowflux data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (2/3 the size of the data) and a validation set (1/3 the size of the data). Then, I created the keras.sequential network model with the following specs— 1) RandomUniform initializer, 2)

inlet layer with 6 neurons (with 3 inputs) with K.elu activation function, 3) 3 hidden layers with 8, 16, and 8 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.0256122 with best epoch at 775). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 2), and second between the prediction vs real data from the normalized validation data set (Figure 3). The mean absolute error between the prediction and the training set was 0.0023915 while the mean absolute error between the prediction and the normalized validation set was 0.002488. Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

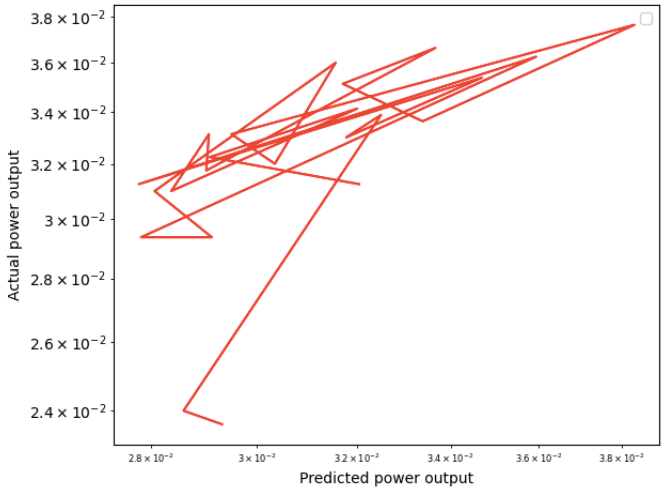

Figure 2. Log-log plot of power output prediction vs given data for trained data using the keras model. It makes a fairly good prediction as can be seen on the graph. The MAE was 0.0023915.

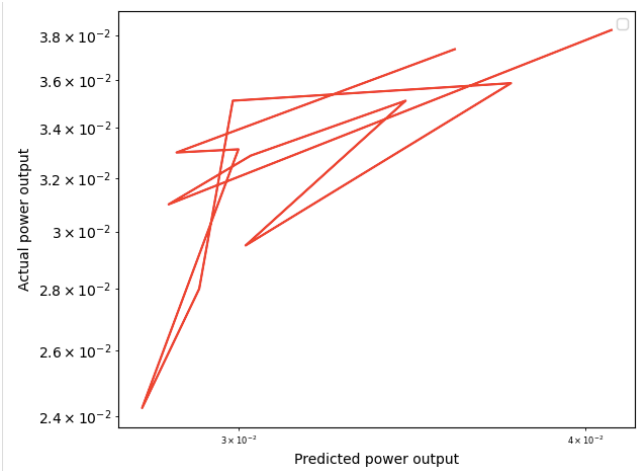

Figure 3. Log-log plot of power output prediction vs given data from the validation set using the trained keras model. It makes a fairly good prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.002483.

The keras model from above was also used to test the normalized Hiflux data given in DS3.1.2Hiflux. The Hiflux data contains data with $I_D > 1300$ W/m^2, and each of the parameters were normalized via dividing each value based on the median of each parameter. The results of the prediction from Hiflux data (based on the keras model) compared to the real data is shown in Figure 4—the mean absolute error between the prediction and the given was 0.969615, which is worse than the Lowflux data by factor of 100. This phenomenon is expected since I_D varies significantly from the data the model was trained based on. Usually, solar radiation intensities max at 1300W/m^2, so the Hiflux data is simply for validation purposes at higher flux levels.

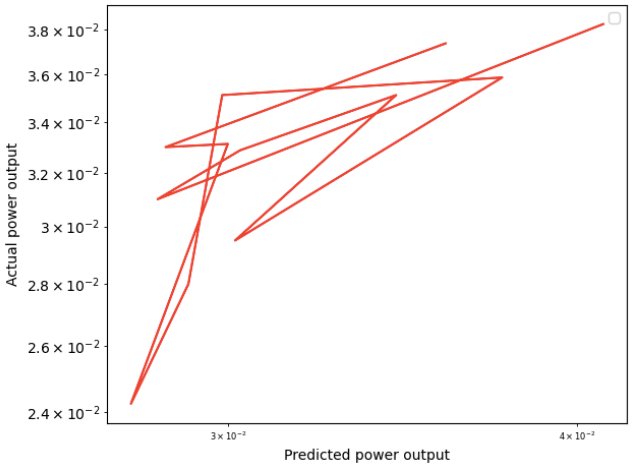

Figure 4. Log-log plot of power output prediction vs given data from the high flux data set using low flux trained keras model. It makes an acceptable prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.969615.

The trained model was used to create a surface plot (Figure 5) of solar power output prediction based on the function of R_L and I_D. Air temperature was fixed at 20 ℃ while $4\ \Omega < R_L < 8\ \Omega$ and $500 < I_D < 1800\ W/m^2$.

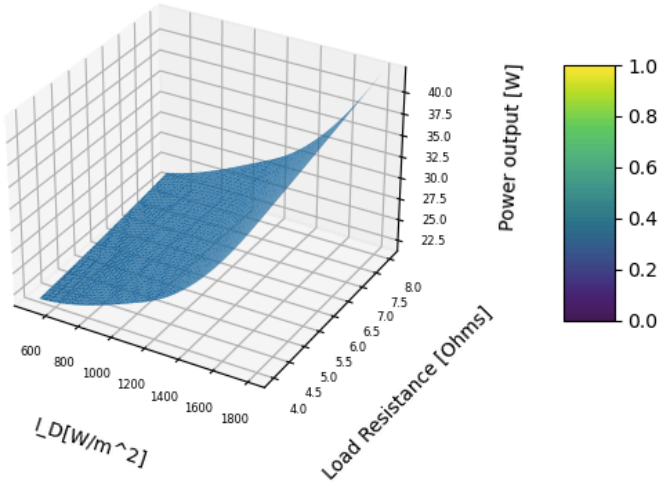

Figure 5. A surface plot for predicted $\dot{W}$ values for $4\ \Omega < R_L < 8\ \Omega$ *and* $500 < I_D < 1800\ W/m^2$ with $T_{air} = 20$℃. As predicted from the eigenvalue, eigenvectors, and scatter plot results in Task 1.1, I_D and R_L influence power output. Also, it can be seen that I_D influences the power output more than R_L.

In task 1.3, I repeated task 1.2 with a new neural network model. The neural network model now has the following specs— 1) RandomUniform initializer, 2) inlet layer with 6 neurons (with 3 inputs) with K.elu activation function, 3) 4 hidden layers with 8, 12, 16, and 8 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0003. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.013608 with best epoch at 767). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 6), and second between the prediction vs real data from the normalized validation data set (Figure 7). The mean absolute error between the prediction and the training set was 0.004687 while the mean absolute error between the prediction and the normalized validation set was 0.004788. Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

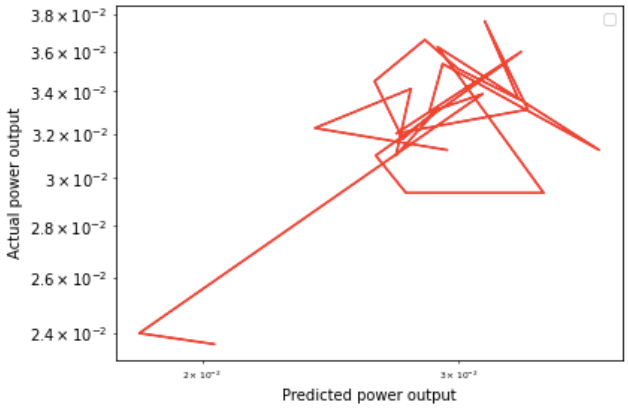

Figure 6. Log-log plot of power output prediction vs given data for trained data using the modified keras model. It makes a fairly good prediction as can be seen on the graph. The MAE was 0.004687.

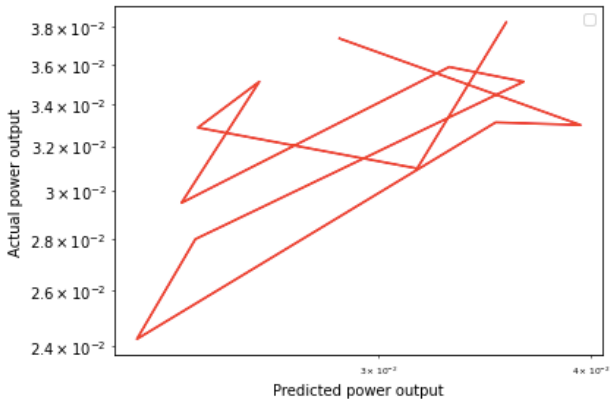

Figure 7. Log-log plot of power output prediction vs given data from the validation set using the modified keras model. It makes a fairly good prediction, but worse compared to the trained set (Figure 6) as can be seen on the graph. The MAE was 0.004788.

The modified keras model from above was also used to test the normalized Hiflux data given in DS3.1.2Hiflux. The Hiflux data contains data with $I_D > 1300$ W/m^2, and each of the parameters were normalized via dividing each value based on the median of each parameter. The results of the prediction from Hiflux data (based on the keras model) compared to the real data is shown in Figure 8—the mean absolute error between the prediction and the given was 0.97004, which is worse than the Lowflux data by factor of 100. This phenomenon is expected since I_D varies significantly from the data the model was trained based on.

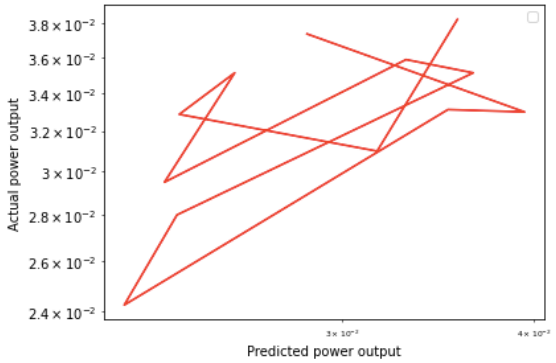

Figure 8. Log-log plot of power output prediction vs given data from the high flux data set using low flux modified keras model. It makes an acceptable prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.97004.

Based on the figures 6-8, it is clear that graphically the modified 4 hidden layers model is a better match of the real data. The one-to-one linear trend is more visible in all of the graphs generated from Task 1.3 compared to those from Task 1.2. However, MAE is statistically comparable for both tasks. Since the loss started to increase although the predictions are more one-to-one with the real data, this is a sign of overfitting of the model. The validation metrics, in this case, mean absolute error loss has improved until a point where it is now getting worse. The trained model was used to create a surface plot (Figure 9) of solar power output prediction based on the function of R_L and I_D. Air temperature was fixed at 20 ℃ while $4\ \Omega < R_L < 8\ \Omega$ and $500 < I_D < 1800\ W/m^2$.

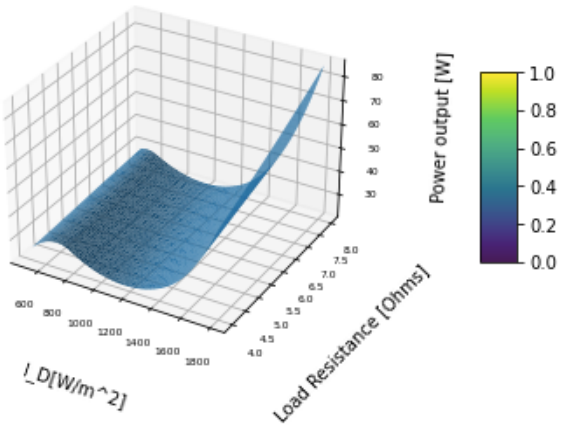

Figure 9. A surface plot for predicted $\dot{W}$ values for $4\ \Omega < R_L < 8\ \Omega$ *and* $500 < I_D < 1800\ W/m^2$ with $T_{air} = 20$℃. As predicted from the eigenvalue, eigenvectors, and scatter plot results in Task 1.1, it can be seen that I_D influences the power output more than R_L. This is a more specified surface plot compared to the one generated from Task 1.2.

Task 2

In task 2, I am looking at a solar PV system comprised of 4 solar panels in 3 different modes—1) 4 in parallel, 2) 2x2 in series/parallel, and 3) 4 in series as shown in Figure 10. Performance data of the system is given as DS3.2.1maxMode with the input data [T_{air}, I_D, R_L] and the output parameters [M_{max}, V_L, $\dot{W}_{max}$].

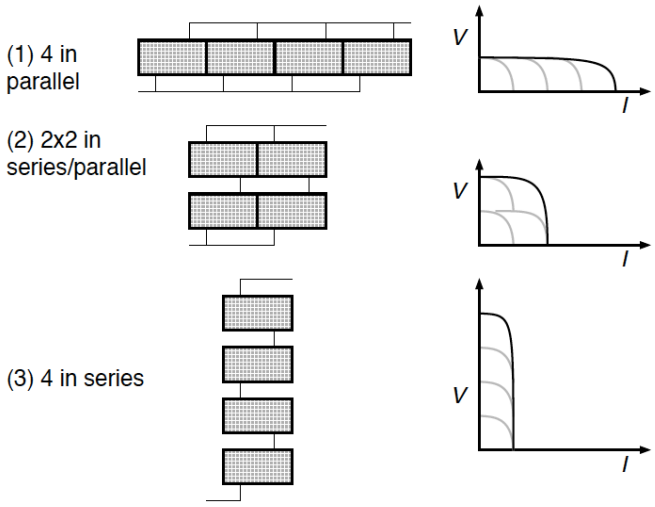

Figure 10. Schematics of solar cell layouts for the different 4 PV panel system modes.

In task 2.1, I built a NN model for predicting the mode that will produce most power for a specified set of operating conditions. First, I normalized the DS3.2.1maxMode data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (3/4 the size of the data) and a validation set (1/4 the size of the data). Then, I created the keras.sequential network model with the following specs— 1) RandomUniform initializer, 2) inlet layer with 16 neurons (with 3 inputs) with K.elu activation function, 3) 3 hidden layers with 32, 16, and 16 neurons all with K.elu activation function, 4) outlet layer with 3 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.025821with best epoch at 688). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 11), and second between the prediction vs real data from the normalized validation data set (Figure 12). The mean absolute error between the prediction and the training set was 0.007073 for M_{max} and 0.0173438 for $\dot{W}_{max}$, while the mean absolute error between the prediction and the normalized validation set was 0.0388 for M_{max} and 0.06592 for $\dot{W}_{max}$,. Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

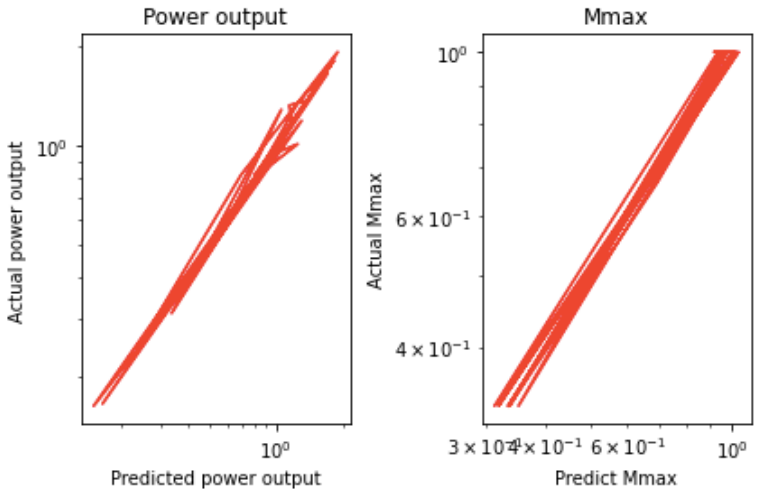

Figure 11. Log-log plot of power output and M_{max} predictions vs given data for trained data using the keras model. As can be seen on the graph, it made pretty great accurate predictions (one-to-one trend) for both power outputs and M_{max}. The MAE was 0.007073 for M_{max} and 0.0173438 for $\dot{W}_{max}$.

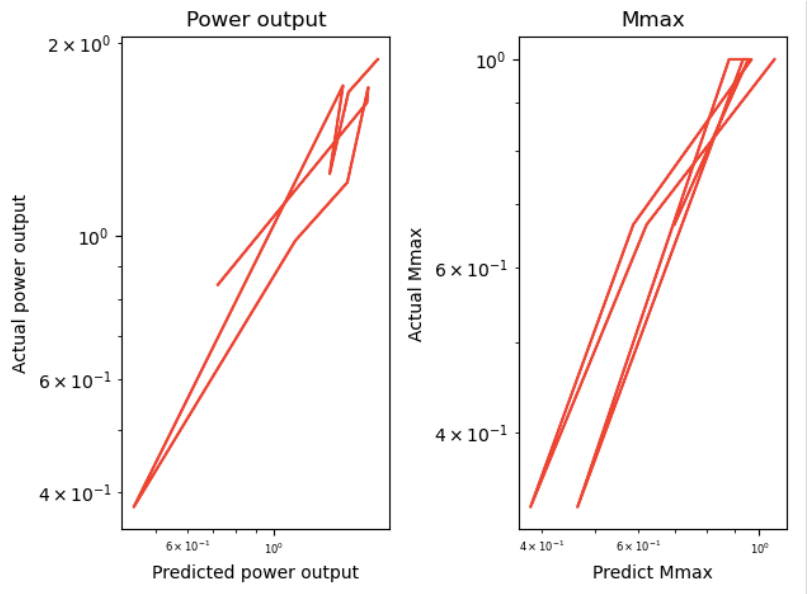

Figure 12. Log-log plot of power output and M_{max} predictions vs given data from the validation set using the keras model. It makes a fairly good prediction (one-to-one trend), but worse compared to the trained set (Figure 11) as can be seen on the graph. The MAE was 0.0388 for M_{max} and 0.06592 for $\dot{W}_{max}$.

In task 2.2, I built a new NN model for predicting the most power output generated for a specified set of operating conditions and mode given. Performance data of the system is given as DS3.2.2multiModePerf with the input data [M, T_{air}, I_D, R_L] and the output parameters [V_L, $\dot{W}_{max}$] for the 4 panel systems. First, I normalized the DS3.2.2multiModePerf data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (3/4 the size of the data) and a validation set (1/4 the size of the data). Then, I created the keras.sequential network model with the following specs— 1) RandomUniform initializer, 2) inlet layer with 16 neurons (with 4 inputs) with K.elu activation function, 3) 3 hidden layers with 32, 16, and 16 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without

an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.0242132 with best epoch at 311). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 13), and second between the prediction vs real data from the normalized validation data set (Figure 14). The mean absolute error between the prediction and the training set was 0.13747 for $\dot{W}_{max}$, while the mean absolute error between the prediction and the normalized validation set was 0.20073 for $\dot{W}_{max}$. Since M is now an input parameter, only the $\dot{W}_{max}$ was compared with MAE. Both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

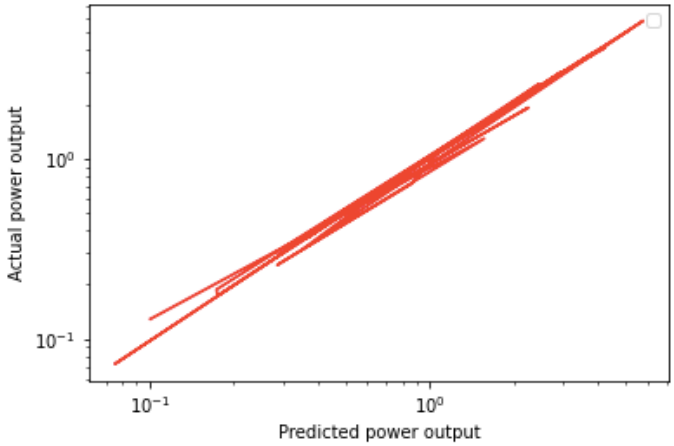

Figure 13. Log-log plot of power output predictions vs given data for trained data using the keras model. As can be seen on the graph, it made pretty great accurate predictions (one-to-one trend) for power outputs. The MAE was 0.13747 for $\dot{W}_{max}$.

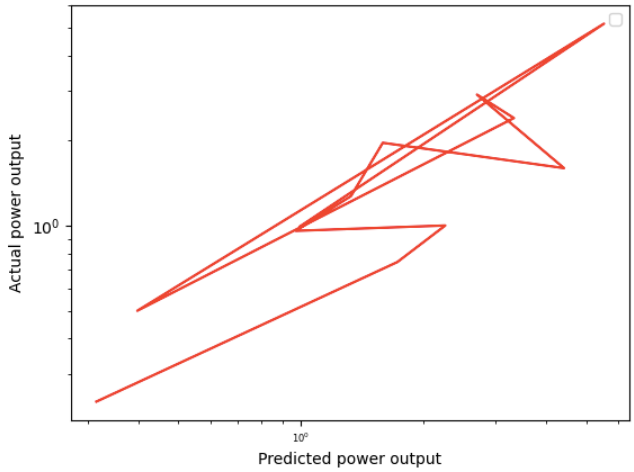

Figure 14. Log-log plot of power output predictions vs given data from the validation set using the keras model. It makes a fairly good prediction (one-to-one trend), but worse compared to the trained set (Figure 13) as can be seen on the graph. The MAE was 0.20073 for $\dot{W}_{max}$.

The keras model generated in Task 2.1 was used to predict M_{max} for the combinations of operating conditions in Table 2. The resulting predictions of M_{max} and $\dot{W}_{max}$ are documented in Table 3.

Table 2. Combinations of operating conditions to be run through the keras model from Task 2.1 [T_{air}, I_D, R_L].

T_{air} (deg, C)	I_D (W/m^2)	R_L (Ohms)
10.0	200	50.
20.0	200	130.
10.0	500	40.
20.0	500	80.
20.0	700	30.
20.	700	55.
10.0	1000	12.
20.0	1000	25.
20.0	1000	39.

Table 3. Combinations of operating conditions [T_{air}, I_D, R_L] and the resulting predictions [M_{max}, V_L, $\dot{W}_{max}$] using keras model generated in Task 2.1.

Tair	I_D	R_L	Mmax	V_L	Wdot
10.0	200	50	1.960221290588379	89.8546043753624	9.899569237232209
20.0	200	130	3.122393488883972	147.61776564121246	10.749907332658767
10.0	500	40	2.7385908365249634	123.95160114765167	22.106579428911207
20.0	500	80	3.0291666984558105	196.10980958938597	27.262160074710845
20.0	700	30	2.7685380578041077	139.9828702688217	33.15414147377014
20.0	700	55	3.175045609474182	199.35400216579436	36.27611528635025
10.0	1000	12	1.8894925117492676	95.91855140924453	46.14515111446381
20.0	1000	25	2.8598315119743347	156.90542230606079	51.35843331813812
20.0	1000	39	3.335097312927246	203.77947695255278	53.72723318338394

Then, the M_{max} predictions from the first model was rounded to the nearest integer to be put through the keras model generated in Task 2.2. Thus, the input parameters were [$[M_{max}]_{rounded}$, T_{air}, I_D, R_L], which was input to the NN model to generate predictions for [V_L, $\dot{W}_{max}$]. All of the data was normalized to the median used to train the data for the respective NN models. The prediction results are shown in Table 4.

Table 4. Combinations of operating conditions [$[M_{max}]_{round}$, T_{air}, I_D, R_L] and the resulting predictions [V_L, $\dot{W}_{max}$] using keras model generated in Task 2.2. The power output predictions are much larger compared to those generated from NN model in Task 2.1.

Mmax_round	Tair	I_D	R_L	V_L	Wdot
2.0	10.0	200	50	91.62284830808639	27.14180871248245
3.0	20.0	200	130	161.88119632005692	23.520206040143965
3.0	10.0	500	40	114.02570812702179	54.815417718887325
3.0	20.0	500	80	148.4456235408783	32.26498575210571
3.0	20.0	700	30	67.31403270959854	21.857767286896706
3.0	20.0	700	55	137.04444386959076	47.840831798315044
2.0	10.0	1000	12	105.40879675149917	151.831032371521
3.0	20.0	1000	25	116.42981876134873	69.384532392025
3.0	20.0	1000	39	180.83092231750487	102.59218779802322

mean absolute error between predictions from first and second model: Wdot = 29.240247532725334

The power output predictions are much greater than the respective values from the NN model predictions from Task 2.1 generated model. The mean absolute error between the $\dot{W}_{max}$ values from the first model vs the second model is 29.24, which is fairly big. The Task 2.1 model is viable for predicting M_{max}, but it is not a viable model for accurately controlling the switch setting in the multi-mode 4 PV panel system described in Figure 10. The difference is due to the second model taking M_{max} into account while the first model does not as an input parameter.

*All neural networks were designed to be K.elu and 3 hidden layers—with respective neurons in each layers mentioned above—to avoid overfitting and to create faster convergence (based on the experimental data from project 2).

Appendix

In [11]:

```
#Task 1.1

import math
import numpy as np
#Part 1 input data: Air temp (degC), ID (W/sqm), load resistance (ohms)
# - split into training set and a randomly slected small validation set
xdata = [[-10.0, 350, 4.464],
  [-10.0, 650, 4.464],
  [-10.0, 950, 4.464],
  [-10.0, 1250, 4.464],
  [10.0, 350, 4.464],
  [10.0, 650, 4.464],
  [10.0, 950, 4.464],
  [10.0, 1250, 4.464],
  [30.0, 350, 4.464],
  [30.0, 650, 4.464],
  [30.0, 950, 4.464],
  [30.0, 1250, 4.464],
  [-10.0, 350, 6.696],
  [-10.0, 650, 6.696],
  [-10.0, 950, 6.696],
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  [30.0, 650, 6.696],
  [30.0, 950, 6.696],
  [30.0, 1250, 6.696],
  [-10.0, 350, 8.928],
  [-10.0, 650, 8.928],
  [-10.0, 950, 8.928],
  [-10.0, 1250, 8.928],
  [10.0, 350, 8.928],
  [10.0, 650, 8.928],
  [10.0, 950, 8.928],
  [10.0, 1250, 8.928],
  [30.0, 350, 8.928],
  [30.0, 650, 8.928],
  [30.0, 950, 8.928],
  [30.0, 1250, 8.928]]


#Part 1 output data: VL (V) and Power out (W)
ydata = [[18.9, 80.3],
 [23.5, 124.6],
 [24.8, 138.6],
 [25.6, 146.9],
 [19.2, 83.1],
 [25.0, 140.5],
```

```
 [26.5, 157.6],
 [27.3, 167.5],
 [19.4, 84.7],
 [26.4, 156.7],
 [28.1, 177.7],
 [29.0, 189.4],
 [22.4, 75.2],
 [24.8, 92.2],
 [25.8, 99.7],
 [26.4, 104.6],
 [23.6, 83.7],
 [26.5, 104.9],
 [27.6, 113.8],
 [28.3, 119.6],
 [24.8, 92.0],
 [28.1, 118.2],
 [29.3, 128.8],
 [30.1, 135.5],
 [23.5, 62.2],
 [25.4, 72.5],
 [26.3, 77.6],
 [26.9, 81.1],
 [25.0, 70.3],
 [27.1, 82.7],
 [28.1, 88.7],
 [28.7, 92.8],
 [26.5, 78.6],
 [28.8, 93.5],
 [29.9, 100.5],
 [30.6, 105.2]]

xarray= np.array(xdata)
yarray= np.array(ydata)
```

In [12]:

```
#Task 1.1a

import statistics as s

Tair =[]
Id =[]
Rl =[]
Tairn =[]
Idn =[]
Rln =[]
xarrayn = []

for x in range(len(xarray)):
    Tair.append(xarray[x][0])
    Id.append(xarray[x][1])
    Rl.append(xarray[x][2])

avgTair = s.mean(Tair)
avgId = s.mean(Id)
avgRl = s.mean(Rl)
sdTair = s.pstdev(Tair)
sdId = s.pstdev(Id)
sdRl = s.pstdev(Rl)

Tairn = (Tair-avgTair)/sdTair
Idn = (Id-avgId)/sdId
Rln = (Rl-avgRl)/sdRl
xarrayn = np.column_stack((Tairn, Idn, Rln))

print(xarrayn)
```

```
[[-1.22474487e+00 -1.34164079e+00 -1.22474487e+00]
 [-1.22474487e+00 -4.47213595e-01 -1.22474487e+00]
 [-1.22474487e+00  4.47213595e-01 -1.22474487e+00]
 [-1.22474487e+00  1.34164079e+00 -1.22474487e+00]
 [ 0.00000000e+00 -1.34164079e+00 -1.22474487e+00]
 [ 0.00000000e+00 -4.47213595e-01 -1.22474487e+00]
 [ 0.00000000e+00  4.47213595e-01 -1.22474487e+00]
 [ 0.00000000e+00  1.34164079e+00 -1.22474487e+00]
 [ 1.22474487e+00 -1.34164079e+00 -1.22474487e+00]
 [ 1.22474487e+00 -4.47213595e-01 -1.22474487e+00]
 [ 1.22474487e+00  4.47213595e-01 -1.22474487e+00]
 [ 1.22474487e+00  1.34164079e+00 -1.22474487e+00]
 [-1.22474487e+00 -1.34164079e+00 -4.87361991e-16]
 [-1.22474487e+00 -4.47213595e-01 -4.87361991e-16]
 [-1.22474487e+00  4.47213595e-01 -4.87361991e-16]
 [-1.22474487e+00  1.34164079e+00 -4.87361991e-16]
 [ 0.00000000e+00 -1.34164079e+00 -4.87361991e-16]
 [ 0.00000000e+00 -4.47213595e-01 -4.87361991e-16]
 [ 0.00000000e+00  4.47213595e-01 -4.87361991e-16]
 [ 0.00000000e+00  1.34164079e+00 -4.87361991e-16]
 [ 1.22474487e+00 -1.34164079e+00 -4.87361991e-16]
 [ 1.22474487e+00 -4.47213595e-01 -4.87361991e-16]
 [ 1.22474487e+00  4.47213595e-01 -4.87361991e-16]
 [ 1.22474487e+00  1.34164079e+00 -4.87361991e-16]
 [-1.22474487e+00 -1.34164079e+00  1.22474487e+00]
 [-1.22474487e+00 -4.47213595e-01  1.22474487e+00]
 [-1.22474487e+00  4.47213595e-01  1.22474487e+00]
 [-1.22474487e+00  1.34164079e+00  1.22474487e+00]
 [ 0.00000000e+00 -1.34164079e+00  1.22474487e+00]
 [ 0.00000000e+00 -4.47213595e-01  1.22474487e+00]
 [ 0.00000000e+00  4.47213595e-01  1.22474487e+00]
 [ 0.00000000e+00  1.34164079e+00  1.22474487e+00]
 [ 1.22474487e+00 -1.34164079e+00  1.22474487e+00]
 [ 1.22474487e+00 -4.47213595e-01  1.22474487e+00]
 [ 1.22474487e+00  4.47213595e-01  1.22474487e+00]
 [ 1.22474487e+00  1.34164079e+00  1.22474487e+00]]
```

In [67]:

```
#Task 1.1b&c - PCA example
import numpy as np
from numpy import linalg as LA
import tensorflow as tf
from tabulate import tabulate

X = xarrayn #define array
C = np.cov(X.T)  #transpose is matrix we want to work with - compute covarian
w, v = LA.eig(C)  # get the eigenvalues w and the eigenvectors v

table = [['Eigenvalues', w],['Eigenvectors',v]]
print(tabulate(table))
```

```
------------  ------------------------------------------------------
Eigenvalues   [1.02857143 1.02857143 1.02857143]
Eigenvectors  [[ 1.00000000e+00 -3.60481637e-02 -1.37997442e-18]
               [ 0.00000000e+00 -9.52653369e-01 -3.02110398e-01]
               [ 0.00000000e+00 -3.01914043e-01  9.53272945e-01]]
------------  ------------------------------------------------------
```

In [81]:

```
# libraries

%matplotlib notebook
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd

fig = plt.figure(figsize=plt.figaspect(0.5))

x=X[:,0]
y=X[:,1]
z=X[:,2]

A  = np.array([v[:,2],v[:,1]])
Xmean = np.mean(X,0)
Y = np.matmul(A,(X-Xmean).T)
xhat = np.matmul(A.T,Y).T + Xmean

xh=xhat[:,0]
yh=xhat[:,1]
zh=xhat[:,2]

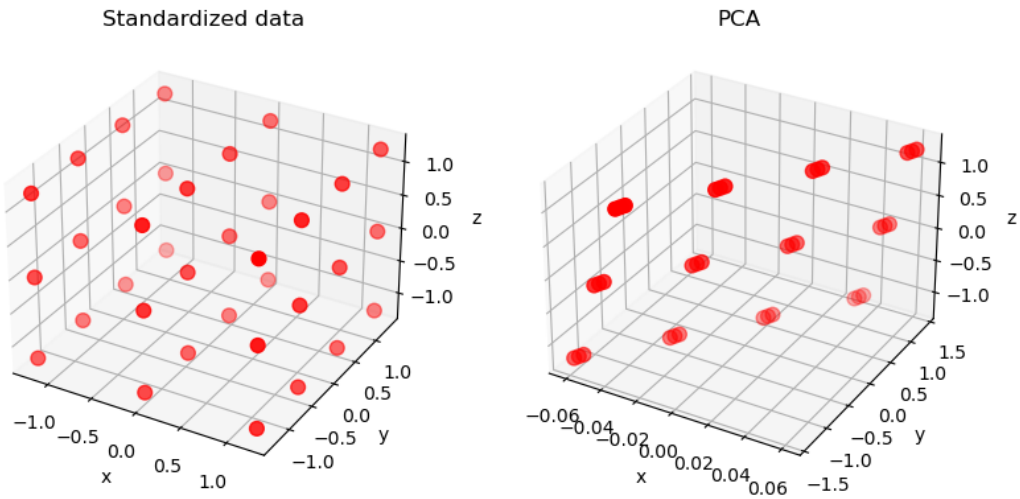
ax = fig.add_subplot(1, 2, 1, projection='3d')
ax.scatter(x,y,z, c='red', s=60)

ax.set_xlabel('x')
ax.set_ylabel('y')
ax.set_zlabel('z')
ax.title.set_text('Standardized data');

ax = fig.add_subplot(1, 2, 2, projection='3d')
ax.scatter(xh,yh,zh, c='red', s=60)

ax.set_xlabel('x')
ax.set_ylabel('y')
ax.set_zlabel('z')
ax.title.set_text('PCA');

plt.show()
```


Standardized data
PCA
x
y
z

In [13]:

```
#Task 1.2 Part a
import keras
import pandas as pd
from keras.models import Sequential
import numpy as np
import keras.backend as kb
import tensorflow as tf
#the follwoing 2 lines are only needed for Mac OS machines
import os
os.environ['KMP_DUPLICATE_LIB_OK']='True'

def median(sample):        #function to calculate median
    n = len(sample)
    i = n//2
    if n%2:
        return sorted (sample [i])
    return sum(sorted(sample)[i-1:i+1])/2

Vl = []
Wdot = []

for y in range(len(yarray)):
    Vl.append(xarray[y][0])
    Wdot.append(xarray[y][1])

medTair = median(Tair)
medId = median(Id)
medRl = median(Rl)
medVl = median(Vl)
medWdot = median(Wdot)

Tairn2 = Tair/medTair
Idn2 = Id/medId
Rln2 = Rl/medRl
Vln2 = Vl/medVl
Wdotn2 = Wdot/medWdot

xarrayn2 = np.column_stack((Tairn2, Idn2, Rln2))
yarrayn2 = np.column_stack((Vln2, Wdotn2))

print(xarrayn2)
print(yarrayn2)
```

```
[[-1.         0.4375     0.66666667]
 [-1.         0.8125     0.66666667]
 [-1.         1.1875     0.66666667]
 [-1.         1.5625     0.66666667]
 [ 1.         0.4375     0.66666667]
 [ 1.         0.8125     0.66666667]
 [ 1.         1.1875     0.66666667]
 [ 1.         1.5625     0.66666667]
 [ 3.         0.4375     0.66666667]
```

```
 [ 3.          0.8125      0.66666667]
 [ 3.          1.1875      0.66666667]
 [ 3.          1.5625      0.66666667]
 [-1.          0.4375      1.        ]
 [-1.          0.8125      1.        ]
 [-1.          1.1875      1.        ]
 [-1.          1.5625      1.        ]
 [ 1.          0.4375      1.        ]
 [ 1.          0.8125      1.        ]
 [ 1.          1.1875      1.        ]
 [ 1.          1.5625      1.        ]
 [ 3.          0.4375      1.        ]
 [ 3.          0.8125      1.        ]
 [ 3.          1.1875      1.        ]
 [ 3.          1.5625      1.        ]
 [-1.          0.4375      1.33333333]
 [-1.          0.8125      1.33333333]
 [-1.          1.1875      1.33333333]
 [-1.          1.5625      1.33333333]
 [ 1.          0.4375      1.33333333]
 [ 1.          0.8125      1.33333333]
 [ 1.          1.1875      1.33333333]
 [ 1.          1.5625      1.33333333]
 [ 3.          0.4375      1.33333333]
 [ 3.          0.8125      1.33333333]
 [ 3.          1.1875      1.33333333]
 [ 3.          1.5625      1.33333333]]
[[-1.      0.4375]
 [-1.      0.8125]
 [-1.      1.1875]
 [-1.      1.5625]
 [ 1.      0.4375]
 [ 1.      0.8125]
 [ 1.      1.1875]
 [ 1.      1.5625]
 [ 3.      0.4375]
 [ 3.      0.8125]
 [ 3.      1.1875]
 [ 3.      1.5625]
 [-1.      0.4375]
 [-1.      0.8125]
 [-1.      1.1875]
 [-1.      1.5625]
 [ 1.      0.4375]
 [ 1.      0.8125]
 [ 1.      1.1875]
 [ 1.      1.5625]
 [ 3.      0.4375]
 [ 3.      0.8125]
 [ 3.      1.1875]
 [ 3.      1.5625]
 [-1.      0.4375]
 [-1.      0.8125]
 [-1.      1.1875]
 [-1.      1.5625]
 [ 1.      0.4375]
 [ 1.      0.8125]
```

```
 [ 1.      1.1875]
 [ 1.      1.5625]
 [ 3.      0.4375]
 [ 3.      0.8125]
 [ 3.      1.1875]
 [ 3.      1.5625]]
```

In [15]:

```
#Task 1.2 Part b
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(xarray, yarray, test_size

print(X_train)
print(y_train)
print(X_test)
print(y_test)
```

```
[[ -10.     350.       4.464]
 [  10.     350.       4.464]
 [  10.     650.       8.928]
 [ -10.    1250.       6.696]
 [  10.    1250.       6.696]
 [  10.     650.       4.464]
 [  30.    1250.       4.464]
 [ -10.     650.       4.464]
 [ -10.     350.       8.928]
 [ -10.     950.       4.464]
 [  30.     650.       8.928]
 [ -10.    1250.       4.464]
 [  30.     350.       8.928]
 [  30.    1250.       6.696]
 [ -10.    1250.       8.928]
 [  30.     950.       4.464]
 [  30.     950.       6.696]
 [  10.     950.       6.696]
 [ -10.     650.       8.928]
 [  10.     950.       4.464]
 [  30.     350.       6.696]
 [  10.    1250.       4.464]
 [ -10.     950.       6.696]
 [  10.     350.       8.928]]
[[ 18.9  80.3]
 [ 19.2  83.1]
 [ 27.1  82.7]
 [ 26.4 104.6]
 [ 28.3 119.6]
 [ 25.  140.5]
 [ 29.  189.4]
 [ 23.5 124.6]
 [ 23.5  62.2]
 [ 24.8 138.6]
 [ 28.8  93.5]
 [ 25.6 146.9]
 [ 26.5  78.6]
 [ 30.1 135.5]
```

```
 [ 26.9  81.1]
 [ 28.1 177.7]
 [ 29.3 128.8]
 [ 27.6 113.8]
 [ 25.4  72.5]
 [ 26.5 157.6]
 [ 24.8  92. ]
 [ 27.3 167.5]
 [ 25.8  99.7]
 [ 25.   70.3]]
[[  30.    1250.       8.928]
 [ -10.     650.       6.696]
 [ -10.     950.       8.928]
 [  10.     950.       8.928]
 [  10.     350.       6.696]
 [  10.    1250.       8.928]
 [  30.     650.       6.696]
 [ -10.     350.       6.696]
 [  30.     350.       4.464]
 [  10.     650.       6.696]
 [  30.     650.       4.464]
 [  30.     950.       8.928]]
[[ 30.6 105.2]
 [ 24.8  92.2]
 [ 26.3  77.6]
 [ 28.1  88.7]
 [ 23.6  83.7]
 [ 28.7  92.8]
 [ 28.1 118.2]
 [ 22.4  75.2]
 [ 19.4  84.7]
 [ 26.5 104.9]
 [ 26.4 156.7]
 [ 29.9 100.5]]
```

In [16]:

```
#normalized data

Tairtrainn = []
Idtrainn = []
Rltrainn = []
Vltrainn = []
Wdottrainn = []
Tairtestn = []
Idtestn = []
Rltestn = []
Vltestn = []
Wdottestn = []

for x in range(len(X_train)):
    Tairtrainn.append(X_train[x][0]/medTair)
    Idtrainn.append(X_train[x][1]/medId)
    Rltrainn.append(X_train[x][2]/medRl)
    Vltrainn.append(y_train[x][0]/medVl)
    Wdottrainn.append(y_train[x][0]/medWdot)

for y in range(len(X_test)):
    Tairtestn.append(X_test[y][0]/medTair)
    Idtestn.append(X_test[y][1]/medId)
    Rltestn.append(X_test[y][2]/medRl)
    Vltestn.append(y_test[y][0]/medVl)
    Wdottestn.append(y_test[y][0]/medWdot)

X_trainn = np.column_stack((Tairtrainn, Idtrainn, Rltrainn))
y_trainn = np.column_stack((Vltrainn, Wdottrainn))
X_testn = np.column_stack((Tairtestn, Idtestn, Rltestn))
y_testn = np.column_stack((Vltestn, Wdottestn))
```

In [366…

```
# define neural network model

from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

model = keras.Sequential([
    keras.layers.Dense(6, activation=K.elu, input_shape=[3],  kernel_initiali
    keras.layers.Dense(8, activation=K.elu,  kernel_initializer=initializer),
    keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(8,  activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(2, kernel_initializer=initializer)
  ])
```

In [384…

```
#from tf.keras import optimizers
rms = keras.optimizers.RMSprop(0.0001)
model.compile(loss='mean_absolute_error',optimizer=rms)
```

In [386…

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 80,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = model.fit(X_trainn,y_trainn,epochs=800,callbacks=[es])

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))

model.save('./best_model')
```

```
Epoch 1/800
24/24 [==============================] - 0s 357us/step - loss: 0.0275
Epoch 2/800
24/24 [==============================] - 0s 308us/step - loss: 0.0278
Epoch 3/800
24/24 [==============================] - 0s 277us/step - loss: 0.0279
Epoch 4/800
24/24 [==============================] - 0s 265us/step - loss: 0.0275
Epoch 5/800
24/24 [==============================] - 0s 251us/step - loss: 0.0275
Epoch 6/800
24/24 [==============================] - 0s 278us/step - loss: 0.0278
Epoch 7/800
24/24 [==============================] - 0s 284us/step - loss: 0.0274
Epoch 8/800
24/24 [==============================] - 0s 222us/step - loss: 0.0278
Epoch 9/800
24/24 [==============================] - 0s 313us/step - loss: 0.0279
Epoch 10/800
24/24 [==============================] - 0s 283us/step - loss: 0.0275
Epoch 11/800
24/24 [==============================] - 0s 329us/step - loss: 0.0274
Epoch 12/800
24/24 [==============================] - 0s 335us/step - loss: 0.0275
Epoch 13/800
24/24 [==============================] - 0s 333us/step - loss: 0.0274
Epoch 14/800
```

```
24/24 [==============================] - 0s 243us/step - loss: 0.0275
Epoch 15/800
24/24 [==============================] - 0s 278us/step - loss: 0.0278
Epoch 16/800
24/24 [==============================] - 0s 340us/step - loss: 0.0284
Epoch 17/800
24/24 [==============================] - 0s 362us/step - loss: 0.0274
Epoch 18/800
24/24 [==============================] - 0s 362us/step - loss: 0.0278
Epoch 19/800
24/24 [==============================] - 0s 361us/step - loss: 0.0279
Epoch 20/800
24/24 [==============================] - 0s 311us/step - loss: 0.0275
Epoch 21/800
24/24 [==============================] - 0s 202us/step - loss: 0.0273
Epoch 22/800
24/24 [==============================] - 0s 177us/step - loss: 0.0274
Epoch 23/800
24/24 [==============================] - 0s 226us/step - loss: 0.0275
Epoch 24/800
24/24 [==============================] - 0s 262us/step - loss: 0.0276
Epoch 25/800
24/24 [==============================] - 0s 343us/step - loss: 0.0276
Epoch 26/800
24/24 [==============================] - 0s 288us/step - loss: 0.0281
Epoch 27/800
24/24 [==============================] - 0s 277us/step - loss: 0.0276
Epoch 28/800
24/24 [==============================] - 0s 257us/step - loss: 0.0275
Epoch 29/800
24/24 [==============================] - 0s 229us/step - loss: 0.0281
Epoch 30/800
24/24 [==============================] - 0s 244us/step - loss: 0.0277
Epoch 31/800
24/24 [==============================] - 0s 376us/step - loss: 0.0274
Epoch 32/800
24/24 [==============================] - 0s 229us/step - loss: 0.0279
Epoch 33/800
24/24 [==============================] - 0s 260us/step - loss: 0.0275
Epoch 34/800
24/24 [==============================] - 0s 272us/step - loss: 0.0275
Epoch 35/800
24/24 [==============================] - 0s 255us/step - loss: 0.0275
Epoch 36/800
24/24 [==============================] - 0s 274us/step - loss: 0.0278
Epoch 37/800
24/24 [==============================] - 0s 226us/step - loss: 0.0278
Epoch 38/800
24/24 [==============================] - 0s 282us/step - loss: 0.0275
Epoch 39/800
24/24 [==============================] - 0s 211us/step - loss: 0.0276
Epoch 40/800
24/24 [==============================] - 0s 221us/step - loss: 0.0279
Epoch 41/800
24/24 [==============================] - 0s 219us/step - loss: 0.0275
Epoch 42/800
24/24 [==============================] - 0s 213us/step - loss: 0.0277
```

```
Epoch 43/800
24/24 [==============================] - 0s 199us/step - loss: 0.0279
Epoch 44/800
24/24 [==============================] - 0s 306us/step - loss: 0.0274
Epoch 45/800
24/24 [==============================] - 0s 190us/step - loss: 0.0276
Epoch 46/800
24/24 [==============================] - 0s 227us/step - loss: 0.0280
Epoch 47/800
24/24 [==============================] - 0s 218us/step - loss: 0.0274
Epoch 48/800
24/24 [==============================] - 0s 184us/step - loss: 0.0275
Epoch 49/800
24/24 [==============================] - 0s 238us/step - loss: 0.0278
Epoch 50/800
24/24 [==============================] - 0s 254us/step - loss: 0.0274
Epoch 51/800
24/24 [==============================] - 0s 190us/step - loss: 0.0275
Epoch 52/800
24/24 [==============================] - 0s 232us/step - loss: 0.0277
Epoch 53/800
24/24 [==============================] - 0s 226us/step - loss: 0.0274
Epoch 54/800
24/24 [==============================] - 0s 225us/step - loss: 0.0273
Epoch 55/800
24/24 [==============================] - 0s 309us/step - loss: 0.0273
Epoch 56/800
24/24 [==============================] - 0s 388us/step - loss: 0.0275
Epoch 57/800
24/24 [==============================] - 0s 424us/step - loss: 0.0273
Epoch 58/800
24/24 [==============================] - 0s 177us/step - loss: 0.0273
Epoch 59/800
24/24 [==============================] - 0s 232us/step - loss: 0.0273
Epoch 60/800
24/24 [==============================] - 0s 314us/step - loss: 0.0278
Epoch 61/800
24/24 [==============================] - 0s 243us/step - loss: 0.0280
Epoch 62/800
24/24 [==============================] - 0s 546us/step - loss: 0.0276
Epoch 63/800
24/24 [==============================] - 0s 332us/step - loss: 0.0277
Epoch 64/800
24/24 [==============================] - 0s 293us/step - loss: 0.0280
Epoch 65/800
24/24 [==============================] - 0s 178us/step - loss: 0.0274
Epoch 66/800
24/24 [==============================] - 0s 205us/step - loss: 0.0276
Epoch 67/800
24/24 [==============================] - 0s 205us/step - loss: 0.0277
Epoch 68/800
24/24 [==============================] - 0s 218us/step - loss: 0.0273
Epoch 69/800
24/24 [==============================] - 0s 201us/step - loss: 0.0275
Epoch 70/800
24/24 [==============================] - 0s 215us/step - loss: 0.0280
Epoch 71/800
```

```
24/24 [==============================] - 0s 184us/step - loss: 0.0273
Epoch 72/800
24/24 [==============================] - 0s 244us/step - loss: 0.0273
Epoch 73/800
24/24 [==============================] - 0s 196us/step - loss: 0.0275
Epoch 74/800
24/24 [==============================] - 0s 215us/step - loss: 0.0278
Epoch 75/800
24/24 [==============================] - 0s 199us/step - loss: 0.0278
Epoch 76/800
24/24 [==============================] - 0s 246us/step - loss: 0.0273
Epoch 77/800
24/24 [==============================] - 0s 211us/step - loss: 0.0274
Epoch 78/800
24/24 [==============================] - 0s 203us/step - loss: 0.0275
Epoch 79/800
24/24 [==============================] - 0s 200us/step - loss: 0.0275
Epoch 80/800
24/24 [==============================] - 0s 182us/step - loss: 0.0278
Epoch 81/800
24/24 [==============================] - 0s 182us/step - loss: 0.0274
Epoch 82/800
24/24 [==============================] - 0s 189us/step - loss: 0.0275
Epoch 83/800
24/24 [==============================] - 0s 204us/step - loss: 0.0279
Epoch 84/800
24/24 [==============================] - 0s 181us/step - loss: 0.0274
Epoch 85/800
24/24 [==============================] - 0s 182us/step - loss: 0.0275
Epoch 86/800
24/24 [==============================] - 0s 186us/step - loss: 0.0280
Epoch 87/800
24/24 [==============================] - 0s 180us/step - loss: 0.0274
Epoch 88/800
24/24 [==============================] - 0s 182us/step - loss: 0.0274
Epoch 89/800
24/24 [==============================] - 0s 221us/step - loss: 0.0277
Epoch 90/800
24/24 [==============================] - 0s 226us/step - loss: 0.0274
Epoch 91/800
24/24 [==============================] - 0s 241us/step - loss: 0.0272
Epoch 92/800
24/24 [==============================] - 0s 215us/step - loss: 0.0273
Epoch 93/800
24/24 [==============================] - 0s 254us/step - loss: 0.0273
Epoch 94/800
24/24 [==============================] - 0s 284us/step - loss: 0.0275
Epoch 95/800
24/24 [==============================] - 0s 245us/step - loss: 0.0275
Epoch 96/800
24/24 [==============================] - 0s 198us/step - loss: 0.0278
Epoch 97/800
24/24 [==============================] - 0s 243us/step - loss: 0.0274
Epoch 98/800
24/24 [==============================] - 0s 184us/step - loss: 0.0277
Epoch 99/800
24/24 [==============================] - 0s 262us/step - loss: 0.0278
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Epoch 100/800
24/24 [==============================] - 0s 225us/step - loss: 0.0273
Epoch 101/800
24/24 [==============================] - 0s 183us/step - loss: 0.0275
Epoch 102/800
24/24 [==============================] - 0s 181us/step - loss: 0.0279
Epoch 103/800
24/24 [==============================] - 0s 214us/step - loss: 0.0273
Epoch 104/800
24/24 [==============================] - 0s 219us/step - loss: 0.0274
Epoch 105/800
24/24 [==============================] - 0s 173us/step - loss: 0.0278
Epoch 106/800
24/24 [==============================] - 0s 201us/step - loss: 0.0273
Epoch 107/800
24/24 [==============================] - 0s 231us/step - loss: 0.0273
Epoch 108/800
24/24 [==============================] - 0s 181us/step - loss: 0.0276
Epoch 109/800
24/24 [==============================] - 0s 172us/step - loss: 0.0273
Epoch 110/800
24/24 [==============================] - 0s 226us/step - loss: 0.0274
Epoch 111/800
24/24 [==============================] - 0s 238us/step - loss: 0.0273
Epoch 112/800
24/24 [==============================] - 0s 213us/step - loss: 0.0276
Epoch 113/800
24/24 [==============================] - 0s 221us/step - loss: 0.0271
Epoch 114/800
24/24 [==============================] - 0s 229us/step - loss: 0.0272
Epoch 115/800
24/24 [==============================] - 0s 230us/step - loss: 0.0272
Epoch 116/800
24/24 [==============================] - 0s 268us/step - loss: 0.0276
Epoch 117/800
24/24 [==============================] - 0s 249us/step - loss: 0.0277
Epoch 118/800
24/24 [==============================] - 0s 250us/step - loss: 0.0273
Epoch 119/800
24/24 [==============================] - 0s 238us/step - loss: 0.0274
Epoch 120/800
24/24 [==============================] - 0s 189us/step - loss: 0.0279
Epoch 121/800
24/24 [==============================] - 0s 215us/step - loss: 0.0274
Epoch 122/800
24/24 [==============================] - 0s 314us/step - loss: 0.0277
Epoch 123/800
24/24 [==============================] - 0s 307us/step - loss: 0.0272
Epoch 124/800
24/24 [==============================] - 0s 287us/step - loss: 0.0273
Epoch 125/800
24/24 [==============================] - 0s 490us/step - loss: 0.0277
Epoch 126/800
24/24 [==============================] - 0s 239us/step - loss: 0.0273
Epoch 127/800
24/24 [==============================] - 0s 191us/step - loss: 0.0273
Epoch 128/800
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24/24 [==============================] - 0s 312us/step - loss: 0.0276
Epoch 129/800
24/24 [==============================] - 0s 477us/step - loss: 0.0272
Epoch 130/800
24/24 [==============================] - 0s 382us/step - loss: 0.0273
Epoch 131/800
24/24 [==============================] - 0s 305us/step - loss: 0.0276
Epoch 132/800
24/24 [==============================] - 0s 178us/step - loss: 0.0275
Epoch 133/800
24/24 [==============================] - 0s 273us/step - loss: 0.0272
Epoch 134/800
24/24 [==============================] - 0s 217us/step - loss: 0.0277
Epoch 135/800
24/24 [==============================] - 0s 186us/step - loss: 0.0273
Epoch 136/800
24/24 [==============================] - 0s 191us/step - loss: 0.0276
Epoch 137/800
24/24 [==============================] - 0s 225us/step - loss: 0.0277
Epoch 138/800
24/24 [==============================] - 0s 215us/step - loss: 0.0272
Epoch 139/800
24/24 [==============================] - 0s 319us/step - loss: 0.0274
Epoch 140/800
24/24 [==============================] - 0s 225us/step - loss: 0.0278
Epoch 141/800
24/24 [==============================] - 0s 173us/step - loss: 0.0272
Epoch 142/800
24/24 [==============================] - 0s 208us/step - loss: 0.0273
Epoch 143/800
24/24 [==============================] - 0s 250us/step - loss: 0.0277
Epoch 144/800
24/24 [==============================] - 0s 253us/step - loss: 0.0272
Epoch 145/800
24/24 [==============================] - 0s 342us/step - loss: 0.0274
Epoch 146/800
24/24 [==============================] - 0s 266us/step - loss: 0.0277
Epoch 147/800
24/24 [==============================] - 0s 517us/step - loss: 0.0271
Epoch 148/800
24/24 [==============================] - 0s 436us/step - loss: 0.0271
Epoch 149/800
24/24 [==============================] - 0s 525us/step - loss: 0.0271
Epoch 150/800
24/24 [==============================] - 0s 401us/step - loss: 0.0272
Epoch 151/800
24/24 [==============================] - 0s 373us/step - loss: 0.0272
Epoch 152/800
24/24 [==============================] - 0s 437us/step - loss: 0.0275
Epoch 153/800
24/24 [==============================] - 0s 254us/step - loss: 0.0273
Epoch 154/800
24/24 [==============================] - 0s 454us/step - loss: 0.0276
Epoch 155/800
24/24 [==============================] - 0s 369us/step - loss: 0.0270
Epoch 156/800
24/24 [==============================] - 0s 599us/step - loss: 0.0272
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Epoch 157/800
24/24 [==============================] - 0s 249us/step - loss: 0.0276
Epoch 158/800
24/24 [==============================] - 0s 195us/step - loss: 0.0273
Epoch 159/800
24/24 [==============================] - 0s 194us/step - loss: 0.0271
Epoch 160/800
24/24 [==============================] - 0s 201us/step - loss: 0.0273
Epoch 161/800
24/24 [==============================] - 0s 241us/step - loss: 0.0274
Epoch 162/800
24/24 [==============================] - 0s 183us/step - loss: 0.0279
Epoch 163/800
24/24 [==============================] - 0s 197us/step - loss: 0.0273
Epoch 164/800
24/24 [==============================] - 0s 204us/step - loss: 0.0274
Epoch 165/800
24/24 [==============================] - 0s 207us/step - loss: 0.0277
Epoch 166/800
24/24 [==============================] - 0s 183us/step - loss: 0.0273
Epoch 167/800
24/24 [==============================] - 0s 183us/step - loss: 0.0273
Epoch 168/800
24/24 [==============================] - 0s 228us/step - loss: 0.0278
Epoch 169/800
24/24 [==============================] - 0s 196us/step - loss: 0.0272
Epoch 170/800
24/24 [==============================] - 0s 241us/step - loss: 0.0273
Epoch 171/800
24/24 [==============================] - 0s 242us/step - loss: 0.0275
Epoch 172/800
24/24 [==============================] - 0s 220us/step - loss: 0.0271
Epoch 173/800
24/24 [==============================] - 0s 184us/step - loss: 0.0271
Epoch 174/800
24/24 [==============================] - 0s 225us/step - loss: 0.0273
Epoch 175/800
24/24 [==============================] - 0s 317us/step - loss: 0.0271
Epoch 176/800
24/24 [==============================] - 0s 278us/step - loss: 0.0272
Epoch 177/800
24/24 [==============================] - 0s 298us/step - loss: 0.0274
Epoch 178/800
24/24 [==============================] - 0s 321us/step - loss: 0.0276
Epoch 179/800
24/24 [==============================] - 0s 330us/step - loss: 0.0271
Epoch 180/800
24/24 [==============================] - 0s 637us/step - loss: 0.0274
Epoch 181/800
24/24 [==============================] - 0s 369us/step - loss: 0.0276
Epoch 182/800
24/24 [==============================] - 0s 598us/step - loss: 0.0274
Epoch 183/800
24/24 [==============================] - 0s 419us/step - loss: 0.0272
Epoch 184/800
24/24 [==============================] - 0s 317us/step - loss: 0.0275
Epoch 185/800
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24/24 [==============================] - 0s 329us/step - loss: 0.0271
Epoch 186/800
24/24 [==============================] - 0s 563us/step - loss: 0.0272
Epoch 187/800
24/24 [==============================] - 0s 435us/step - loss: 0.0276
Epoch 188/800
24/24 [==============================] - 0s 323us/step - loss: 0.0274
Epoch 189/800
24/24 [==============================] - 0s 448us/step - loss: 0.0271
Epoch 190/800
24/24 [==============================] - 0s 495us/step - loss: 0.0274
Epoch 191/800
24/24 [==============================] - 0s 368us/step - loss: 0.0270
Epoch 192/800
24/24 [==============================] - 0s 397us/step - loss: 0.0271
Epoch 193/800
24/24 [==============================] - 0s 579us/step - loss: 0.0272
Epoch 194/800
24/24 [==============================] - 0s 333us/step - loss: 0.0277
Epoch 195/800
24/24 [==============================] - 0s 299us/step - loss: 0.0271
Epoch 196/800
24/24 [==============================] - 0s 352us/step - loss: 0.0271
Epoch 197/800
24/24 [==============================] - 0s 273us/step - loss: 0.0272
Epoch 198/800
24/24 [==============================] - 0s 565us/step - loss: 0.0276
Epoch 199/800
24/24 [==============================] - 0s 304us/step - loss: 0.0275
Epoch 200/800
24/24 [==============================] - 0s 317us/step - loss: 0.0271
Epoch 201/800
24/24 [==============================] - 0s 253us/step - loss: 0.0272
Epoch 202/800
24/24 [==============================] - 0s 357us/step - loss: 0.0275
Epoch 203/800
24/24 [==============================] - 0s 223us/step - loss: 0.0271
Epoch 204/800
24/24 [==============================] - 0s 289us/step - loss: 0.0272
Epoch 205/800
24/24 [==============================] - 0s 225us/step - loss: 0.0275
Epoch 206/800
24/24 [==============================] - 0s 240us/step - loss: 0.0272
Epoch 207/800
24/24 [==============================] - 0s 236us/step - loss: 0.0273
Epoch 208/800
24/24 [==============================] - 0s 271us/step - loss: 0.0276
Epoch 209/800
24/24 [==============================] - 0s 321us/step - loss: 0.0270
Epoch 210/800
24/24 [==============================] - 0s 313us/step - loss: 0.0270
Epoch 211/800
24/24 [==============================] - 0s 274us/step - loss: 0.0271
Epoch 212/800
24/24 [==============================] - 0s 254us/step - loss: 0.0274
Epoch 213/800
24/24 [==============================] - 0s 308us/step - loss: 0.0270
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Epoch 214/800
24/24 [==============================] - 0s 553us/step - loss: 0.0271
Epoch 215/800
24/24 [==============================] - 0s 342us/step - loss: 0.0272
Epoch 216/800
24/24 [==============================] - 0s 546us/step - loss: 0.0277
Epoch 217/800
24/24 [==============================] - 0s 343us/step - loss: 0.0275
Epoch 218/800
24/24 [==============================] - 0s 294us/step - loss: 0.0270
Epoch 219/800
24/24 [==============================] - 0s 255us/step - loss: 0.0270
Epoch 220/800
24/24 [==============================] - 0s 428us/step - loss: 0.0271
Epoch 221/800
24/24 [==============================] - 0s 312us/step - loss: 0.0273
Epoch 222/800
24/24 [==============================] - 0s 239us/step - loss: 0.0277
Epoch 223/800
24/24 [==============================] - 0s 361us/step - loss: 0.0270
Epoch 224/800
24/24 [==============================] - 0s 440us/step - loss: 0.0272
Epoch 225/800
24/24 [==============================] - 0s 270us/step - loss: 0.0274
Epoch 226/800
24/24 [==============================] - 0s 406us/step - loss: 0.0271
Epoch 227/800
24/24 [==============================] - 0s 204us/step - loss: 0.0272
Epoch 228/800
24/24 [==============================] - 0s 285us/step - loss: 0.0276
Epoch 229/800
24/24 [==============================] - 0s 539us/step - loss: 0.0269
Epoch 230/800
24/24 [==============================] - 0s 256us/step - loss: 0.0269
Epoch 231/800
24/24 [==============================] - 0s 217us/step - loss: 0.0270
Epoch 232/800
24/24 [==============================] - 0s 277us/step - loss: 0.0274
Epoch 233/800
24/24 [==============================] - 0s 280us/step - loss: 0.0271
Epoch 234/800
24/24 [==============================] - 0s 288us/step - loss: 0.0275
Epoch 235/800
24/24 [==============================] - 0s 281us/step - loss: 0.0270
Epoch 236/800
24/24 [==============================] - 0s 229us/step - loss: 0.0273
Epoch 237/800
24/24 [==============================] - 0s 208us/step - loss: 0.0275
Epoch 238/800
24/24 [==============================] - 0s 171us/step - loss: 0.0269
Epoch 239/800
24/24 [==============================] - 0s 311us/step - loss: 0.0269
Epoch 240/800
24/24 [==============================] - 0s 238us/step - loss: 0.0270
Epoch 241/800
24/24 [==============================] - 0s 246us/step - loss: 0.0273
Epoch 242/800
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24/24 [==============================] - 0s 583us/step - loss: 0.0278
Epoch 243/800
24/24 [==============================] - 0s 490us/step - loss: 0.0270
Epoch 244/800
24/24 [==============================] - 0s 246us/step - loss: 0.0271
Epoch 245/800
24/24 [==============================] - 0s 418us/step - loss: 0.0274
Epoch 246/800
24/24 [==============================] - 0s 661us/step - loss: 0.0271
Epoch 247/800
24/24 [==============================] - 0s 381us/step - loss: 0.0271
Epoch 248/800
24/24 [==============================] - 0s 629us/step - loss: 0.0273
Epoch 249/800
24/24 [==============================] - 0s 291us/step - loss: 0.0268
Epoch 250/800
24/24 [==============================] - 0s 309us/step - loss: 0.0269
Epoch 251/800
24/24 [==============================] - 0s 270us/step - loss: 0.0269
Epoch 252/800
24/24 [==============================] - 0s 259us/step - loss: 0.0271
Epoch 253/800
24/24 [==============================] - 0s 248us/step - loss: 0.0273
Epoch 254/800
24/24 [==============================] - 0s 224us/step - loss: 0.0279
Epoch 255/800
24/24 [==============================] - 0s 293us/step - loss: 0.0274
Epoch 256/800
24/24 [==============================] - 0s 207us/step - loss: 0.0269
Epoch 257/800
24/24 [==============================] - 0s 196us/step - loss: 0.0268
Epoch 258/800
24/24 [==============================] - 0s 194us/step - loss: 0.0270
Epoch 259/800
24/24 [==============================] - 0s 190us/step - loss: 0.0272
Epoch 260/800
24/24 [==============================] - 0s 288us/step - loss: 0.0278
Epoch 261/800
24/24 [==============================] - 0s 223us/step - loss: 0.0270
Epoch 262/800
24/24 [==============================] - 0s 294us/step - loss: 0.0271
Epoch 263/800
24/24 [==============================] - 0s 262us/step - loss: 0.0274
Epoch 264/800
24/24 [==============================] - 0s 265us/step - loss: 0.0270
Epoch 265/800
24/24 [==============================] - 0s 252us/step - loss: 0.0271
Epoch 266/800
24/24 [==============================] - 0s 217us/step - loss: 0.0273
Epoch 267/800
24/24 [==============================] - 0s 195us/step - loss: 0.0269
Epoch 268/800
24/24 [==============================] - 0s 195us/step - loss: 0.0270
Epoch 269/800
24/24 [==============================] - 0s 231us/step - loss: 0.0271
Epoch 270/800
24/24 [==============================] - 0s 206us/step - loss: 0.0272
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Epoch 271/800
24/24 [==============================] - 0s 283us/step - loss: 0.0271
Epoch 272/800
24/24 [==============================] - 0s 240us/step - loss: 0.0269
Epoch 273/800
24/24 [==============================] - 0s 213us/step - loss: 0.0269
Epoch 274/800
24/24 [==============================] - 0s 211us/step - loss: 0.0271
Epoch 275/800
24/24 [==============================] - 0s 223us/step - loss: 0.0274
Epoch 276/800
24/24 [==============================] - 0s 238us/step - loss: 0.0270
Epoch 277/800
24/24 [==============================] - 0s 240us/step - loss: 0.0272
Epoch 278/800
24/24 [==============================] - 0s 204us/step - loss: 0.0275
Epoch 279/800
24/24 [==============================] - 0s 285us/step - loss: 0.0270
Epoch 280/800
24/24 [==============================] - 0s 269us/step - loss: 0.0271
Epoch 281/800
24/24 [==============================] - 0s 195us/step - loss: 0.0273
Epoch 282/800
24/24 [==============================] - 0s 220us/step - loss: 0.0269
Epoch 283/800
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Epoch 284/800
24/24 [==============================] - 0s 234us/step - loss: 0.0273
Epoch 285/800
24/24 [==============================] - 0s 248us/step - loss: 0.0270
Epoch 286/800
24/24 [==============================] - 0s 250us/step - loss: 0.0273
Epoch 287/800
24/24 [==============================] - 0s 239us/step - loss: 0.0270
Epoch 288/800
24/24 [==============================] - 0s 276us/step - loss: 0.0270
Epoch 289/800
24/24 [==============================] - 0s 233us/step - loss: 0.0268
Epoch 290/800
24/24 [==============================] - 0s 240us/step - loss: 0.0269
Epoch 291/800
24/24 [==============================] - 0s 295us/step - loss: 0.0271
Epoch 292/800
24/24 [==============================] - 0s 256us/step - loss: 0.0275
Epoch 293/800
24/24 [==============================] - 0s 296us/step - loss: 0.0269
Epoch 294/800
24/24 [==============================] - 0s 241us/step - loss: 0.0271
Epoch 295/800
24/24 [==============================] - 0s 187us/step - loss: 0.0274
Epoch 296/800
24/24 [==============================] - 0s 210us/step - loss: 0.0271
Epoch 297/800
24/24 [==============================] - 0s 391us/step - loss: 0.0268
Epoch 298/800
24/24 [==============================] - 0s 262us/step - loss: 0.0272
Epoch 299/800
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24/24 [==============================] - 0s 330us/step - loss: 0.0267
Epoch 300/800
24/24 [==============================] - 0s 219us/step - loss: 0.0268
Epoch 301/800
24/24 [==============================] - 0s 279us/step - loss: 0.0268
Epoch 302/800
24/24 [==============================] - 0s 217us/step - loss: 0.0269
Epoch 303/800
24/24 [==============================] - 0s 259us/step - loss: 0.0270
Epoch 304/800
24/24 [==============================] - 0s 245us/step - loss: 0.0275
Epoch 305/800
24/24 [==============================] - 0s 243us/step - loss: 0.0269
Epoch 306/800
24/24 [==============================] - 0s 268us/step - loss: 0.0270
Epoch 307/800
24/24 [==============================] - 0s 261us/step - loss: 0.0274
Epoch 308/800
24/24 [==============================] - 0s 208us/step - loss: 0.0270
Epoch 309/800
24/24 [==============================] - 0s 182us/step - loss: 0.0269
Epoch 310/800
24/24 [==============================] - 0s 202us/step - loss: 0.0271
Epoch 311/800
24/24 [==============================] - 0s 217us/step - loss: 0.0270
Epoch 312/800
24/24 [==============================] - 0s 321us/step - loss: 0.0273
Epoch 313/800
24/24 [==============================] - 0s 260us/step - loss: 0.0269
Epoch 314/800
24/24 [==============================] - 0s 200us/step - loss: 0.0271
Epoch 315/800
24/24 [==============================] - 0s 278us/step - loss: 0.0274
Epoch 316/800
24/24 [==============================] - 0s 291us/step - loss: 0.0270
Epoch 317/800
24/24 [==============================] - 0s 255us/step - loss: 0.0271
Epoch 318/800
24/24 [==============================] - 0s 239us/step - loss: 0.0274
Epoch 319/800
24/24 [==============================] - 0s 220us/step - loss: 0.0269
Epoch 320/800
24/24 [==============================] - 0s 198us/step - loss: 0.0270
Epoch 321/800
24/24 [==============================] - 0s 275us/step - loss: 0.0272
Epoch 322/800
24/24 [==============================] - 0s 190us/step - loss: 0.0268
Epoch 323/800
24/24 [==============================] - 0s 255us/step - loss: 0.0268
Epoch 324/800
24/24 [==============================] - 0s 255us/step - loss: 0.0272
Epoch 325/800
24/24 [==============================] - 0s 220us/step - loss: 0.0269
Epoch 326/800
24/24 [==============================] - 0s 252us/step - loss: 0.0272
Epoch 327/800
24/24 [==============================] - 0s 265us/step - loss: 0.0268
```

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Epoch 328/800
24/24 [==============================] - 0s 244us/step - loss: 0.0270
Epoch 329/800
24/24 [==============================] - 0s 276us/step - loss: 0.0271
Epoch 330/800
24/24 [==============================] - 0s 212us/step - loss: 0.0268
Epoch 331/800
24/24 [==============================] - 0s 188us/step - loss: 0.0269
Epoch 332/800
24/24 [==============================] - 0s 213us/step - loss: 0.0274
Epoch 333/800
24/24 [==============================] - 0s 249us/step - loss: 0.0267
Epoch 334/800
24/24 [==============================] - 0s 291us/step - loss: 0.0268
Epoch 335/800
24/24 [==============================] - 0s 271us/step - loss: 0.0270
Epoch 336/800
24/24 [==============================] - 0s 407us/step - loss: 0.0268
Epoch 337/800
24/24 [==============================] - 0s 288us/step - loss: 0.0267
Epoch 338/800
24/24 [==============================] - 0s 303us/step - loss: 0.0273
Epoch 339/800
24/24 [==============================] - 0s 292us/step - loss: 0.0268
Epoch 340/800
24/24 [==============================] - 0s 222us/step - loss: 0.0270
Epoch 341/800
24/24 [==============================] - 0s 220us/step - loss: 0.0267
Epoch 342/800
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Epoch 343/800
24/24 [==============================] - 0s 261us/step - loss: 0.0273
Epoch 344/800
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Epoch 345/800
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Epoch 346/800
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Epoch 347/800
24/24 [==============================] - 0s 215us/step - loss: 0.0268
Epoch 348/800
24/24 [==============================] - 0s 224us/step - loss: 0.0275
Epoch 349/800
24/24 [==============================] - 0s 287us/step - loss: 0.0273
Epoch 350/800
24/24 [==============================] - 0s 261us/step - loss: 0.0268
Epoch 351/800
24/24 [==============================] - 0s 274us/step - loss: 0.0267
Epoch 352/800
24/24 [==============================] - 0s 206us/step - loss: 0.0270
Epoch 353/800
24/24 [==============================] - 0s 265us/step - loss: 0.0267
Epoch 354/800
24/24 [==============================] - 0s 219us/step - loss: 0.0269
Epoch 355/800
24/24 [==============================] - 0s 243us/step - loss: 0.0268
Epoch 356/800
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24/24 [==============================] - 0s 200us/step - loss: 0.0272
Epoch 357/800
24/24 [==============================] - 0s 176us/step - loss: 0.0268
Epoch 358/800
24/24 [==============================] - 0s 288us/step - loss: 0.0269
Epoch 359/800
24/24 [==============================] - 0s 230us/step - loss: 0.0273
Epoch 360/800
24/24 [==============================] - 0s 228us/step - loss: 0.0269
Epoch 361/800
24/24 [==============================] - 0s 256us/step - loss: 0.0268
Epoch 362/800
24/24 [==============================] - 0s 317us/step - loss: 0.0269
Epoch 363/800
24/24 [==============================] - 0s 180us/step - loss: 0.0267
Epoch 364/800
24/24 [==============================] - 0s 227us/step - loss: 0.0268
Epoch 365/800
24/24 [==============================] - 0s 231us/step - loss: 0.0269
Epoch 366/800
24/24 [==============================] - 0s 204us/step - loss: 0.0273
Epoch 367/800
24/24 [==============================] - 0s 247us/step - loss: 0.0268
Epoch 368/800
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Epoch 369/800
24/24 [==============================] - 0s 219us/step - loss: 0.0272
Epoch 370/800
24/24 [==============================] - 0s 162us/step - loss: 0.0270
Epoch 371/800
24/24 [==============================] - 0s 188us/step - loss: 0.0267
Epoch 372/800
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Epoch 373/800
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Epoch 374/800
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Epoch 375/800
24/24 [==============================] - 0s 241us/step - loss: 0.0271
Epoch 376/800
24/24 [==============================] - 0s 170us/step - loss: 0.0268
Epoch 377/800
24/24 [==============================] - 0s 194us/step - loss: 0.0269
Epoch 378/800
24/24 [==============================] - 0s 257us/step - loss: 0.0271
Epoch 379/800
24/24 [==============================] - 0s 297us/step - loss: 0.0266
Epoch 380/800
24/24 [==============================] - 0s 226us/step - loss: 0.0268
Epoch 381/800
24/24 [==============================] - 0s 219us/step - loss: 0.0271
Epoch 382/800
24/24 [==============================] - 0s 246us/step - loss: 0.0272
Epoch 383/800
24/24 [==============================] - 0s 242us/step - loss: 0.0267
Epoch 384/800
24/24 [==============================] - 0s 224us/step - loss: 0.0270
```

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Epoch 385/800
24/24 [==============================] - 0s 173us/step - loss: 0.0265
Epoch 386/800
24/24 [==============================] - 0s 232us/step - loss: 0.0265
Epoch 387/800
24/24 [==============================] - 0s 260us/step - loss: 0.0270
Epoch 388/800
24/24 [==============================] - 0s 314us/step - loss: 0.0267
Epoch 389/800
24/24 [==============================] - 0s 200us/step - loss: 0.0267
Epoch 390/800
24/24 [==============================] - 0s 188us/step - loss: 0.0270
Epoch 391/800
24/24 [==============================] - 0s 223us/step - loss: 0.0269
Epoch 392/800
24/24 [==============================] - 0s 228us/step - loss: 0.0273
Epoch 393/800
24/24 [==============================] - 0s 234us/step - loss: 0.0267
Epoch 394/800
24/24 [==============================] - 0s 238us/step - loss: 0.0267
Epoch 395/800
24/24 [==============================] - 0s 236us/step - loss: 0.0272
Epoch 396/800
24/24 [==============================] - 0s 185us/step - loss: 0.0268
Epoch 397/800
24/24 [==============================] - 0s 211us/step - loss: 0.0266
Epoch 398/800
24/24 [==============================] - 0s 201us/step - loss: 0.0270
Epoch 399/800
24/24 [==============================] - 0s 223us/step - loss: 0.0267
Epoch 400/800
24/24 [==============================] - 0s 194us/step - loss: 0.0267
Epoch 401/800
24/24 [==============================] - 0s 288us/step - loss: 0.0268
Epoch 402/800
24/24 [==============================] - 0s 220us/step - loss: 0.0273
Epoch 403/800
24/24 [==============================] - 0s 199us/step - loss: 0.0268
Epoch 404/800
24/24 [==============================] - 0s 218us/step - loss: 0.0268
Epoch 405/800
24/24 [==============================] - 0s 173us/step - loss: 0.0269
Epoch 406/800
24/24 [==============================] - 0s 328us/step - loss: 0.0271
Epoch 407/800
24/24 [==============================] - 0s 228us/step - loss: 0.0272
Epoch 408/800
24/24 [==============================] - 0s 228us/step - loss: 0.0266
Epoch 409/800
24/24 [==============================] - 0s 242us/step - loss: 0.0267
Epoch 410/800
24/24 [==============================] - 0s 351us/step - loss: 0.0272
Epoch 411/800
24/24 [==============================] - 0s 265us/step - loss: 0.0268
Epoch 412/800
24/24 [==============================] - 0s 299us/step - loss: 0.0268
Epoch 413/800
```

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24/24 [==============================] - 0s 310us/step - loss: 0.0266
Epoch 414/800
24/24 [==============================] - 0s 264us/step - loss: 0.0265
Epoch 415/800
24/24 [==============================] - 0s 188us/step - loss: 0.0266
Epoch 416/800
24/24 [==============================] - 0s 254us/step - loss: 0.0268
Epoch 417/800
24/24 [==============================] - 0s 295us/step - loss: 0.0267
Epoch 418/800
24/24 [==============================] - 0s 277us/step - loss: 0.0269
Epoch 419/800
24/24 [==============================] - 0s 212us/step - loss: 0.0271
Epoch 420/800
24/24 [==============================] - 0s 202us/step - loss: 0.0267
Epoch 421/800
24/24 [==============================] - 0s 289us/step - loss: 0.0270
Epoch 422/800
24/24 [==============================] - 0s 286us/step - loss: 0.0275
Epoch 423/800
24/24 [==============================] - 0s 267us/step - loss: 0.0266
Epoch 424/800
24/24 [==============================] - 0s 203us/step - loss: 0.0267
Epoch 425/800
24/24 [==============================] - 0s 242us/step - loss: 0.0270
Epoch 426/800
24/24 [==============================] - 0s 303us/step - loss: 0.0266
Epoch 427/800
24/24 [==============================] - 0s 484us/step - loss: 0.0266
Epoch 428/800
24/24 [==============================] - 0s 243us/step - loss: 0.0270
Epoch 429/800
24/24 [==============================] - 0s 344us/step - loss: 0.0266
Epoch 430/800
24/24 [==============================] - 0s 304us/step - loss: 0.0266
Epoch 431/800
24/24 [==============================] - 0s 383us/step - loss: 0.0266
Epoch 432/800
24/24 [==============================] - 0s 388us/step - loss: 0.0266
Epoch 433/800
24/24 [==============================] - 0s 350us/step - loss: 0.0268
Epoch 434/800
24/24 [==============================] - 0s 357us/step - loss: 0.0273
Epoch 435/800
24/24 [==============================] - 0s 387us/step - loss: 0.0270
Epoch 436/800
24/24 [==============================] - 0s 495us/step - loss: 0.0265
Epoch 437/800
24/24 [==============================] - 0s 361us/step - loss: 0.0268
Epoch 438/800
24/24 [==============================] - 0s 797us/step - loss: 0.0272
Epoch 439/800
24/24 [==============================] - 0s 441us/step - loss: 0.0266
Epoch 440/800
24/24 [==============================] - 0s 328us/step - loss: 0.0265
Epoch 441/800
24/24 [==============================] - 0s 338us/step - loss: 0.0268
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Epoch 442/800
24/24 [==============================] - 0s 270us/step - loss: 0.0266
Epoch 443/800
24/24 [==============================] - 0s 192us/step - loss: 0.0266
Epoch 444/800
24/24 [==============================] - 0s 197us/step - loss: 0.0268
Epoch 445/800
24/24 [==============================] - 0s 262us/step - loss: 0.0267
Epoch 446/800
24/24 [==============================] - 0s 250us/step - loss: 0.0269
Epoch 447/800
24/24 [==============================] - 0s 239us/step - loss: 0.0264
Epoch 448/800
24/24 [==============================] - 0s 193us/step - loss: 0.0264
Epoch 449/800
24/24 [==============================] - 0s 229us/step - loss: 0.0264
Epoch 450/800
24/24 [==============================] - 0s 333us/step - loss: 0.0268
Epoch 451/800
24/24 [==============================] - 0s 250us/step - loss: 0.0268
Epoch 452/800
24/24 [==============================] - 0s 279us/step - loss: 0.0274
Epoch 453/800
24/24 [==============================] - 0s 250us/step - loss: 0.0267
Epoch 454/800
24/24 [==============================] - 0s 367us/step - loss: 0.0268
Epoch 455/800
24/24 [==============================] - 0s 361us/step - loss: 0.0269
Epoch 456/800
24/24 [==============================] - 0s 477us/step - loss: 0.0265
Epoch 457/800
24/24 [==============================] - 0s 241us/step - loss: 0.0265
Epoch 458/800
24/24 [==============================] - 0s 307us/step - loss: 0.0268
Epoch 459/800
24/24 [==============================] - 0s 452us/step - loss: 0.0264
Epoch 460/800
24/24 [==============================] - 0s 367us/step - loss: 0.0268
Epoch 461/800
24/24 [==============================] - 0s 300us/step - loss: 0.0267
Epoch 462/800
24/24 [==============================] - 0s 421us/step - loss: 0.0269
Epoch 463/800
24/24 [==============================] - 0s 248us/step - loss: 0.0265
Epoch 464/800
24/24 [==============================] - 0s 295us/step - loss: 0.0266
Epoch 465/800
24/24 [==============================] - 0s 274us/step - loss: 0.0268
Epoch 466/800
24/24 [==============================] - 0s 273us/step - loss: 0.0270
Epoch 467/800
24/24 [==============================] - 0s 392us/step - loss: 0.0269
Epoch 468/800
24/24 [==============================] - 0s 241us/step - loss: 0.0265
Epoch 469/800
24/24 [==============================] - 0s 273us/step - loss: 0.0263
Epoch 470/800
```

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24/24 [==============================] - 0s 278us/step - loss: 0.0264
Epoch 471/800
24/24 [==============================] - 0s 210us/step - loss: 0.0266
Epoch 472/800
24/24 [==============================] - 0s 209us/step - loss: 0.0263
Epoch 473/800
24/24 [==============================] - 0s 339us/step - loss: 0.0264
Epoch 474/800
24/24 [==============================] - 0s 777us/step - loss: 0.0267
Epoch 475/800
24/24 [==============================] - 0s 484us/step - loss: 0.0270
Epoch 476/800
24/24 [==============================] - 0s 634us/step - loss: 0.0265
Epoch 477/800
24/24 [==============================] - 0s 253us/step - loss: 0.0267
Epoch 478/800
24/24 [==============================] - 0s 247us/step - loss: 0.0277
Epoch 479/800
24/24 [==============================] - 0s 214us/step - loss: 0.0265
Epoch 480/800
24/24 [==============================] - 0s 191us/step - loss: 0.0268
Epoch 481/800
24/24 [==============================] - 0s 233us/step - loss: 0.0267
Epoch 482/800
24/24 [==============================] - 0s 197us/step - loss: 0.0266
Epoch 483/800
24/24 [==============================] - 0s 197us/step - loss: 0.0267
Epoch 484/800
24/24 [==============================] - 0s 194us/step - loss: 0.0262
Epoch 485/800
24/24 [==============================] - 0s 236us/step - loss: 0.0267
Epoch 486/800
24/24 [==============================] - 0s 253us/step - loss: 0.0270
Epoch 487/800
24/24 [==============================] - 0s 278us/step - loss: 0.0267
Epoch 488/800
24/24 [==============================] - 0s 385us/step - loss: 0.0270
Epoch 489/800
24/24 [==============================] - 0s 247us/step - loss: 0.0269
Epoch 490/800
24/24 [==============================] - 0s 274us/step - loss: 0.0264
Epoch 491/800
24/24 [==============================] - 0s 244us/step - loss: 0.0264
Epoch 492/800
24/24 [==============================] - 0s 305us/step - loss: 0.0266
Epoch 493/800
24/24 [==============================] - 0s 254us/step - loss: 0.0264
Epoch 494/800
24/24 [==============================] - 0s 185us/step - loss: 0.0266
Epoch 495/800
24/24 [==============================] - 0s 255us/step - loss: 0.0268
Epoch 496/800
24/24 [==============================] - 0s 235us/step - loss: 0.0273
Epoch 497/800
24/24 [==============================] - 0s 188us/step - loss: 0.0267
Epoch 498/800
24/24 [==============================] - 0s 200us/step - loss: 0.0264
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Epoch 499/800
24/24 [==============================] - 0s 218us/step - loss: 0.0267
Epoch 500/800
24/24 [==============================] - 0s 180us/step - loss: 0.0263
Epoch 501/800
24/24 [==============================] - 0s 233us/step - loss: 0.0264
Epoch 502/800
24/24 [==============================] - 0s 206us/step - loss: 0.0266
Epoch 503/800
24/24 [==============================] - 0s 214us/step - loss: 0.0264
Epoch 504/800
24/24 [==============================] - 0s 263us/step - loss: 0.0266
Epoch 505/800
24/24 [==============================] - 0s 218us/step - loss: 0.0266
Epoch 506/800
24/24 [==============================] - 0s 244us/step - loss: 0.0272
Epoch 507/800
24/24 [==============================] - 0s 316us/step - loss: 0.0265
Epoch 508/800
24/24 [==============================] - 0s 252us/step - loss: 0.0267
Epoch 509/800
24/24 [==============================] - 0s 235us/step - loss: 0.0269
Epoch 510/800
24/24 [==============================] - 0s 231us/step - loss: 0.0265
Epoch 511/800
24/24 [==============================] - 0s 206us/step - loss: 0.0264
Epoch 512/800
24/24 [==============================] - 0s 231us/step - loss: 0.0267
Epoch 513/800
24/24 [==============================] - 0s 208us/step - loss: 0.0263
Epoch 514/800
24/24 [==============================] - 0s 215us/step - loss: 0.0263
Epoch 515/800
24/24 [==============================] - 0s 192us/step - loss: 0.0265
Epoch 516/800
24/24 [==============================] - 0s 242us/step - loss: 0.0265
Epoch 517/800
24/24 [==============================] - 0s 247us/step - loss: 0.0269
Epoch 518/800
24/24 [==============================] - 0s 197us/step - loss: 0.0265
Epoch 519/800
24/24 [==============================] - 0s 208us/step - loss: 0.0265
Epoch 520/800
24/24 [==============================] - 0s 214us/step - loss: 0.0266
Epoch 521/800
24/24 [==============================] - 0s 248us/step - loss: 0.0264
Epoch 522/800
24/24 [==============================] - 0s 214us/step - loss: 0.0267
Epoch 523/800
24/24 [==============================] - 0s 244us/step - loss: 0.0263
Epoch 524/800
24/24 [==============================] - 0s 210us/step - loss: 0.0265
Epoch 525/800
24/24 [==============================] - 0s 268us/step - loss: 0.0269
Epoch 526/800
24/24 [==============================] - 0s 252us/step - loss: 0.0268
Epoch 527/800
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24/24 [==============================] - 0s 252us/step - loss: 0.0263
Epoch 528/800
24/24 [==============================] - 0s 242us/step - loss: 0.0264
Epoch 529/800
24/24 [==============================] - 0s 254us/step - loss: 0.0265
Epoch 530/800
24/24 [==============================] - 0s 232us/step - loss: 0.0272
Epoch 531/800
24/24 [==============================] - 0s 227us/step - loss: 0.0266
Epoch 532/800
24/24 [==============================] - 0s 223us/step - loss: 0.0262
Epoch 533/800
24/24 [==============================] - 0s 214us/step - loss: 0.0265
Epoch 534/800
24/24 [==============================] - 0s 251us/step - loss: 0.0265
Epoch 535/800
24/24 [==============================] - 0s 252us/step - loss: 0.0269
Epoch 536/800
24/24 [==============================] - 0s 369us/step - loss: 0.0271
Epoch 537/800
24/24 [==============================] - 0s 423us/step - loss: 0.0265
Epoch 538/800
24/24 [==============================] - 0s 688us/step - loss: 0.0265
Epoch 539/800
24/24 [==============================] - 0s 520us/step - loss: 0.0262
Epoch 540/800
24/24 [==============================] - 0s 493us/step - loss: 0.0266
Epoch 541/800
24/24 [==============================] - 0s 414us/step - loss: 0.0262
Epoch 542/800
24/24 [==============================] - 0s 348us/step - loss: 0.0264
Epoch 543/800
24/24 [==============================] - 0s 310us/step - loss: 0.0267
Epoch 544/800
24/24 [==============================] - 0s 329us/step - loss: 0.0264
Epoch 545/800
24/24 [==============================] - 0s 285us/step - loss: 0.0263
Epoch 546/800
24/24 [==============================] - 0s 316us/step - loss: 0.0265
Epoch 547/800
24/24 [==============================] - 0s 206us/step - loss: 0.0264
Epoch 548/800
24/24 [==============================] - 0s 261us/step - loss: 0.0266
Epoch 549/800
24/24 [==============================] - 0s 226us/step - loss: 0.0262
Epoch 550/800
24/24 [==============================] - 0s 237us/step - loss: 0.0267
Epoch 551/800
24/24 [==============================] - 0s 199us/step - loss: 0.0272
Epoch 552/800
24/24 [==============================] - 0s 322us/step - loss: 0.0270
Epoch 553/800
24/24 [==============================] - 0s 264us/step - loss: 0.0265
Epoch 554/800
24/24 [==============================] - 0s 282us/step - loss: 0.0270
Epoch 555/800
24/24 [==============================] - 0s 320us/step - loss: 0.0264
```

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Epoch 556/800
24/24 [==============================] - 0s 311us/step - loss: 0.0262
Epoch 557/800
24/24 [==============================] - 0s 387us/step - loss: 0.0266
Epoch 558/800
24/24 [==============================] - 0s 411us/step - loss: 0.0269
Epoch 559/800
24/24 [==============================] - 0s 563us/step - loss: 0.0264
Epoch 560/800
24/24 [==============================] - 0s 423us/step - loss: 0.0263
Epoch 561/800
24/24 [==============================] - 0s 381us/step - loss: 0.0265
Epoch 562/800
24/24 [==============================] - 0s 406us/step - loss: 0.0263
Epoch 563/800
24/24 [==============================] - 0s 288us/step - loss: 0.0262
Epoch 564/800
24/24 [==============================] - 0s 351us/step - loss: 0.0266
Epoch 565/800
24/24 [==============================] - 0s 434us/step - loss: 0.0262
Epoch 566/800
24/24 [==============================] - 0s 479us/step - loss: 0.0263
Epoch 567/800
24/24 [==============================] - 0s 467us/step - loss: 0.0266
Epoch 568/800
24/24 [==============================] - 0s 275us/step - loss: 0.0264
Epoch 569/800
24/24 [==============================] - 0s 266us/step - loss: 0.0267
Epoch 570/800
24/24 [==============================] - 0s 301us/step - loss: 0.0262
Epoch 571/800
24/24 [==============================] - 0s 287us/step - loss: 0.0263
Epoch 572/800
24/24 [==============================] - 0s 201us/step - loss: 0.0267
Epoch 573/800
24/24 [==============================] - 0s 187us/step - loss: 0.0264
Epoch 574/800
24/24 [==============================] - 0s 187us/step - loss: 0.0268
Epoch 575/800
24/24 [==============================] - 0s 210us/step - loss: 0.0268
Epoch 576/800
24/24 [==============================] - 0s 193us/step - loss: 0.0269
Epoch 577/800
24/24 [==============================] - 0s 201us/step - loss: 0.0263
Epoch 578/800
24/24 [==============================] - 0s 184us/step - loss: 0.0265
Epoch 579/800
24/24 [==============================] - 0s 211us/step - loss: 0.0267
Epoch 580/800
24/24 [==============================] - 0s 225us/step - loss: 0.0264
Epoch 581/800
24/24 [==============================] - 0s 315us/step - loss: 0.0262
Epoch 582/800
24/24 [==============================] - 0s 271us/step - loss: 0.0267
Epoch 583/800
24/24 [==============================] - 0s 205us/step - loss: 0.0263
Epoch 584/800
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24/24 [==============================] - 0s 250us/step - loss: 0.0264
Epoch 585/800
24/24 [==============================] - 0s 191us/step - loss: 0.0265
Epoch 586/800
24/24 [==============================] - 0s 292us/step - loss: 0.0265
Epoch 587/800
24/24 [==============================] - 0s 241us/step - loss: 0.0265
Epoch 588/800
24/24 [==============================] - 0s 227us/step - loss: 0.0261
Epoch 589/800
24/24 [==============================] - 0s 173us/step - loss: 0.0261
Epoch 590/800
24/24 [==============================] - 0s 214us/step - loss: 0.0263
Epoch 591/800
24/24 [==============================] - 0s 201us/step - loss: 0.0265
Epoch 592/800
24/24 [==============================] - 0s 194us/step - loss: 0.0260
Epoch 593/800
24/24 [==============================] - 0s 203us/step - loss: 0.0263
Epoch 594/800
24/24 [==============================] - 0s 263us/step - loss: 0.0271
Epoch 595/800
24/24 [==============================] - 0s 254us/step - loss: 0.0263
Epoch 596/800
24/24 [==============================] - 0s 321us/step - loss: 0.0265
Epoch 597/800
24/24 [==============================] - 0s 285us/step - loss: 0.0265
Epoch 598/800
24/24 [==============================] - 0s 287us/step - loss: 0.0262
Epoch 599/800
24/24 [==============================] - 0s 219us/step - loss: 0.0262
Epoch 600/800
24/24 [==============================] - 0s 253us/step - loss: 0.0264
Epoch 601/800
24/24 [==============================] - 0s 205us/step - loss: 0.0267
Epoch 602/800
24/24 [==============================] - 0s 230us/step - loss: 0.0263
Epoch 603/800
24/24 [==============================] - 0s 230us/step - loss: 0.0264
Epoch 604/800
24/24 [==============================] - 0s 233us/step - loss: 0.0272
Epoch 605/800
24/24 [==============================] - 0s 232us/step - loss: 0.0264
Epoch 606/800
24/24 [==============================] - 0s 267us/step - loss: 0.0266
Epoch 607/800
24/24 [==============================] - 0s 262us/step - loss: 0.0262
Epoch 608/800
24/24 [==============================] - 0s 302us/step - loss: 0.0264
Epoch 609/800
24/24 [==============================] - 0s 231us/step - loss: 0.0266
Epoch 610/800
24/24 [==============================] - 0s 302us/step - loss: 0.0262
Epoch 611/800
24/24 [==============================] - 0s 253us/step - loss: 0.0263
Epoch 612/800
24/24 [==============================] - 0s 365us/step - loss: 0.0267
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Epoch 613/800
24/24 [==============================] - 0s 347us/step - loss: 0.0262
Epoch 614/800
24/24 [==============================] - 0s 324us/step - loss: 0.0264
Epoch 615/800
24/24 [==============================] - 0s 380us/step - loss: 0.0265
Epoch 616/800
24/24 [==============================] - 0s 503us/step - loss: 0.0264
Epoch 617/800
24/24 [==============================] - 0s 377us/step - loss: 0.0264
Epoch 618/800
24/24 [==============================] - 0s 534us/step - loss: 0.0266
Epoch 619/800
24/24 [==============================] - 0s 352us/step - loss: 0.0268
Epoch 620/800
24/24 [==============================] - 0s 316us/step - loss: 0.0264
Epoch 621/800
24/24 [==============================] - 0s 340us/step - loss: 0.0261
Epoch 622/800
24/24 [==============================] - 0s 267us/step - loss: 0.0266
Epoch 623/800
24/24 [==============================] - 0s 334us/step - loss: 0.0261
Epoch 624/800
24/24 [==============================] - 0s 232us/step - loss: 0.0261
Epoch 625/800
24/24 [==============================] - 0s 245us/step - loss: 0.0260
Epoch 626/800
24/24 [==============================] - 0s 349us/step - loss: 0.0262
Epoch 627/800
24/24 [==============================] - 0s 190us/step - loss: 0.0267
Epoch 628/800
24/24 [==============================] - 0s 254us/step - loss: 0.0263
Epoch 629/800
24/24 [==============================] - 0s 306us/step - loss: 0.0266
Epoch 630/800
24/24 [==============================] - 0s 258us/step - loss: 0.0268
Epoch 631/800
24/24 [==============================] - 0s 322us/step - loss: 0.0262
Epoch 632/800
24/24 [==============================] - 0s 297us/step - loss: 0.0265
Epoch 633/800
24/24 [==============================] - 0s 232us/step - loss: 0.0264
Epoch 634/800
24/24 [==============================] - 0s 428us/step - loss: 0.0261
Epoch 635/800
24/24 [==============================] - 0s 362us/step - loss: 0.0261
Epoch 636/800
24/24 [==============================] - 0s 341us/step - loss: 0.0265
Epoch 637/800
24/24 [==============================] - 0s 384us/step - loss: 0.0261
Epoch 638/800
24/24 [==============================] - 0s 453us/step - loss: 0.0261
Epoch 639/800
24/24 [==============================] - 0s 420us/step - loss: 0.0264
Epoch 640/800
24/24 [==============================] - 0s 476us/step - loss: 0.0260
Epoch 641/800
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24/24 [==============================] - 0s 334us/step - loss: 0.0261
Epoch 642/800
24/24 [==============================] - 0s 427us/step - loss: 0.0265
Epoch 643/800
24/24 [==============================] - 0s 448us/step - loss: 0.0266
Epoch 644/800
24/24 [==============================] - 0s 292us/step - loss: 0.0271
Epoch 645/800
24/24 [==============================] - 0s 305us/step - loss: 0.0261
Epoch 646/800
24/24 [==============================] - 0s 353us/step - loss: 0.0263
Epoch 647/800
24/24 [==============================] - 0s 597us/step - loss: 0.0266
Epoch 648/800
24/24 [==============================] - 0s 315us/step - loss: 0.0262
Epoch 649/800
24/24 [==============================] - 0s 288us/step - loss: 0.0262
Epoch 650/800
24/24 [==============================] - 0s 331us/step - loss: 0.0266
Epoch 651/800
24/24 [==============================] - 0s 273us/step - loss: 0.0261
Epoch 652/800
24/24 [==============================] - 0s 377us/step - loss: 0.0266
Epoch 653/800
24/24 [==============================] - 0s 243us/step - loss: 0.0265
Epoch 654/800
24/24 [==============================] - 0s 476us/step - loss: 0.0262
Epoch 655/800
24/24 [==============================] - 0s 252us/step - loss: 0.0261
Epoch 656/800
24/24 [==============================] - 0s 282us/step - loss: 0.0265
Epoch 657/800
24/24 [==============================] - 0s 249us/step - loss: 0.0264
Epoch 658/800
24/24 [==============================] - 0s 182us/step - loss: 0.0268
Epoch 659/800
24/24 [==============================] - 0s 196us/step - loss: 0.0262
Epoch 660/800
24/24 [==============================] - 0s 223us/step - loss: 0.0263
Epoch 661/800
24/24 [==============================] - 0s 218us/step - loss: 0.0259
Epoch 662/800
24/24 [==============================] - 0s 204us/step - loss: 0.0261
Epoch 663/800
24/24 [==============================] - 0s 221us/step - loss: 0.0263
Epoch 664/800
24/24 [==============================] - 0s 220us/step - loss: 0.0262
Epoch 665/800
24/24 [==============================] - 0s 345us/step - loss: 0.0265
Epoch 666/800
24/24 [==============================] - 0s 208us/step - loss: 0.0262
Epoch 667/800
24/24 [==============================] - 0s 183us/step - loss: 0.0263
Epoch 668/800
24/24 [==============================] - 0s 171us/step - loss: 0.0267
Epoch 669/800
24/24 [==============================] - 0s 210us/step - loss: 0.0261
```

```
Epoch 670/800
24/24 [==============================] - 0s 230us/step - loss: 0.0260
Epoch 671/800
24/24 [==============================] - 0s 205us/step - loss: 0.0263
Epoch 672/800
24/24 [==============================] - 0s 283us/step - loss: 0.0261
Epoch 673/800
24/24 [==============================] - 0s 221us/step - loss: 0.0264
Epoch 674/800
24/24 [==============================] - 0s 197us/step - loss: 0.0270
Epoch 675/800
24/24 [==============================] - 0s 276us/step - loss: 0.0263
Epoch 676/800
24/24 [==============================] - 0s 237us/step - loss: 0.0260
Epoch 677/800
24/24 [==============================] - 0s 198us/step - loss: 0.0259
Epoch 678/800
24/24 [==============================] - 0s 212us/step - loss: 0.0266
Epoch 679/800
24/24 [==============================] - 0s 170us/step - loss: 0.0260
Epoch 680/800
24/24 [==============================] - 0s 172us/step - loss: 0.0260
Epoch 681/800
24/24 [==============================] - 0s 244us/step - loss: 0.0262
Epoch 682/800
24/24 [==============================] - 0s 277us/step - loss: 0.0261
Epoch 683/800
24/24 [==============================] - 0s 214us/step - loss: 0.0264
Epoch 684/800
24/24 [==============================] - 0s 270us/step - loss: 0.0260
Epoch 685/800
24/24 [==============================] - 0s 225us/step - loss: 0.0263
Epoch 686/800
24/24 [==============================] - 0s 233us/step - loss: 0.0265
Epoch 687/800
24/24 [==============================] - 0s 261us/step - loss: 0.0260
Epoch 688/800
24/24 [==============================] - 0s 304us/step - loss: 0.0266
Epoch 689/800
24/24 [==============================] - 0s 241us/step - loss: 0.0265
Epoch 690/800
24/24 [==============================] - 0s 328us/step - loss: 0.0262
Epoch 691/800
24/24 [==============================] - 0s 230us/step - loss: 0.0262
Epoch 692/800
24/24 [==============================] - 0s 207us/step - loss: 0.0263
Epoch 693/800
24/24 [==============================] - 0s 359us/step - loss: 0.0260
Epoch 694/800
24/24 [==============================] - 0s 266us/step - loss: 0.0264
Epoch 695/800
24/24 [==============================] - 0s 272us/step - loss: 0.0259
Epoch 696/800
24/24 [==============================] - 0s 337us/step - loss: 0.0260
Epoch 697/800
24/24 [==============================] - 0s 281us/step - loss: 0.0263
Epoch 698/800
```

```
24/24 [==============================] - 0s 251us/step - loss: 0.0267
Epoch 699/800
24/24 [==============================] - 0s 296us/step - loss: 0.0264
Epoch 700/800
24/24 [==============================] - 0s 286us/step - loss: 0.0261
Epoch 701/800
24/24 [==============================] - 0s 214us/step - loss: 0.0261
Epoch 702/800
24/24 [==============================] - 0s 274us/step - loss: 0.0264
Epoch 703/800
24/24 [==============================] - 0s 245us/step - loss: 0.0262
Epoch 704/800
24/24 [==============================] - 0s 288us/step - loss: 0.0259
Epoch 705/800
24/24 [==============================] - 0s 184us/step - loss: 0.0261
Epoch 706/800
24/24 [==============================] - 0s 223us/step - loss: 0.0258
Epoch 707/800
24/24 [==============================] - 0s 242us/step - loss: 0.0262
Epoch 708/800
24/24 [==============================] - 0s 212us/step - loss: 0.0257
Epoch 709/800
24/24 [==============================] - 0s 208us/step - loss: 0.0258
Epoch 710/800
24/24 [==============================] - 0s 228us/step - loss: 0.0262
Epoch 711/800
24/24 [==============================] - 0s 240us/step - loss: 0.0263
Epoch 712/800
24/24 [==============================] - 0s 363us/step - loss: 0.0266
Epoch 713/800
24/24 [==============================] - 0s 365us/step - loss: 0.0268
Epoch 714/800
24/24 [==============================] - 0s 257us/step - loss: 0.0267
Epoch 715/800
24/24 [==============================] - 0s 196us/step - loss: 0.0265
Epoch 716/800
24/24 [==============================] - 0s 246us/step - loss: 0.0259
Epoch 717/800
24/24 [==============================] - 0s 282us/step - loss: 0.0262
Epoch 718/800
24/24 [==============================] - 0s 209us/step - loss: 0.0262
Epoch 719/800
24/24 [==============================] - 0s 297us/step - loss: 0.0260
Epoch 720/800
24/24 [==============================] - 0s 233us/step - loss: 0.0261
Epoch 721/800
24/24 [==============================] - 0s 201us/step - loss: 0.0257
Epoch 722/800
24/24 [==============================] - 0s 304us/step - loss: 0.0262
Epoch 723/800
24/24 [==============================] - 0s 338us/step - loss: 0.0259
Epoch 724/800
24/24 [==============================] - 0s 482us/step - loss: 0.0259
Epoch 725/800
24/24 [==============================] - 0s 344us/step - loss: 0.0267
Epoch 726/800
24/24 [==============================] - 0s 377us/step - loss: 0.0261
```

```
Epoch 727/800
24/24 [==============================] - 0s 625us/step - loss: 0.0269
Epoch 728/800
24/24 [==============================] - 0s 330us/step - loss: 0.0264
Epoch 729/800
24/24 [==============================] - 0s 542us/step - loss: 0.0260
Epoch 730/800
24/24 [==============================] - 0s 341us/step - loss: 0.0260
Epoch 731/800
24/24 [==============================] - 0s 310us/step - loss: 0.0265
Epoch 732/800
24/24 [==============================] - 0s 212us/step - loss: 0.0261
Epoch 733/800
24/24 [==============================] - 0s 254us/step - loss: 0.0259
Epoch 734/800
24/24 [==============================] - 0s 404us/step - loss: 0.0260
Epoch 735/800
24/24 [==============================] - 0s 363us/step - loss: 0.0260
Epoch 736/800
24/24 [==============================] - 0s 459us/step - loss: 0.0265
Epoch 737/800
24/24 [==============================] - 0s 322us/step - loss: 0.0261
Epoch 738/800
24/24 [==============================] - 0s 223us/step - loss: 0.0261
Epoch 739/800
24/24 [==============================] - 0s 316us/step - loss: 0.0265
Epoch 740/800
24/24 [==============================] - 0s 525us/step - loss: 0.0260
Epoch 741/800
24/24 [==============================] - 0s 363us/step - loss: 0.0260
Epoch 742/800
24/24 [==============================] - 0s 515us/step - loss: 0.0260
Epoch 743/800
24/24 [==============================] - 0s 759us/step - loss: 0.0257
Epoch 744/800
24/24 [==============================] - 0s 352us/step - loss: 0.0261
Epoch 745/800
24/24 [==============================] - 0s 639us/step - loss: 0.0262
Epoch 746/800
24/24 [==============================] - 0s 469us/step - loss: 0.0263
Epoch 747/800
24/24 [==============================] - 0s 616us/step - loss: 0.0270
Epoch 748/800
24/24 [==============================] - 0s 277us/step - loss: 0.0259
Epoch 749/800
24/24 [==============================] - 0s 216us/step - loss: 0.0258
Epoch 750/800
24/24 [==============================] - 0s 313us/step - loss: 0.0261
Epoch 751/800
24/24 [==============================] - 0s 622us/step - loss: 0.0265
Epoch 752/800
24/24 [==============================] - 0s 262us/step - loss: 0.0261
Epoch 753/800
24/24 [==============================] - 0s 279us/step - loss: 0.0260
Epoch 754/800
24/24 [==============================] - 0s 212us/step - loss: 0.0261
Epoch 755/800
```

```
24/24 [==============================] - 0s 359us/step - loss: 0.0263
Epoch 756/800
24/24 [==============================] - 0s 463us/step - loss: 0.0264
Epoch 757/800
24/24 [==============================] - 0s 272us/step - loss: 0.0259
Epoch 758/800
24/24 [==============================] - 0s 228us/step - loss: 0.0260
Epoch 759/800
24/24 [==============================] - 0s 223us/step - loss: 0.0265
Epoch 760/800
24/24 [==============================] - 0s 277us/step - loss: 0.0260
Epoch 761/800
24/24 [==============================] - 0s 276us/step - loss: 0.0260
Epoch 762/800
24/24 [==============================] - 0s 245us/step - loss: 0.0261
Epoch 763/800
24/24 [==============================] - 0s 290us/step - loss: 0.0258
Epoch 764/800
24/24 [==============================] - 0s 432us/step - loss: 0.0259
Epoch 765/800
24/24 [==============================] - 0s 235us/step - loss: 0.0261
Epoch 766/800
24/24 [==============================] - 0s 411us/step - loss: 0.0263
Epoch 767/800
24/24 [==============================] - 0s 314us/step - loss: 0.0259
Epoch 768/800
24/24 [==============================] - 0s 493us/step - loss: 0.0262
Epoch 769/800
24/24 [==============================] - 0s 291us/step - loss: 0.0266
Epoch 770/800
24/24 [==============================] - 0s 449us/step - loss: 0.0265
Epoch 771/800
24/24 [==============================] - 0s 384us/step - loss: 0.0265
Epoch 772/800
24/24 [==============================] - 0s 419us/step - loss: 0.0260
Epoch 773/800
24/24 [==============================] - 0s 457us/step - loss: 0.0259
Epoch 774/800
24/24 [==============================] - 0s 349us/step - loss: 0.0261
Epoch 775/800
24/24 [==============================] - 0s 343us/step - loss: 0.0256
Epoch 776/800
24/24 [==============================] - 0s 250us/step - loss: 0.0259
Epoch 777/800
24/24 [==============================] - 0s 434us/step - loss: 0.0262
Epoch 778/800
24/24 [==============================] - 0s 201us/step - loss: 0.0259
Epoch 779/800
24/24 [==============================] - 0s 222us/step - loss: 0.0264
Epoch 780/800
24/24 [==============================] - 0s 265us/step - loss: 0.0259
Epoch 781/800
24/24 [==============================] - 0s 266us/step - loss: 0.0260
Epoch 782/800
24/24 [==============================] - 0s 191us/step - loss: 0.0261
Epoch 783/800
24/24 [==============================] - 0s 260us/step - loss: 0.0262
```

```
Epoch 784/800
24/24 [==============================] - 0s 300us/step - loss: 0.0263
Epoch 785/800
24/24 [==============================] - 0s 243us/step - loss: 0.0258
Epoch 786/800
24/24 [==============================] - 0s 241us/step - loss: 0.0260
Epoch 787/800
24/24 [==============================] - 0s 288us/step - loss: 0.0263
Epoch 788/800
24/24 [==============================] - 0s 244us/step - loss: 0.0258
Epoch 789/800
24/24 [==============================] - 0s 237us/step - loss: 0.0259
Epoch 790/800
24/24 [==============================] - 0s 227us/step - loss: 0.0262
Epoch 791/800
24/24 [==============================] - 0s 181us/step - loss: 0.0258
Epoch 792/800
24/24 [==============================] - 0s 211us/step - loss: 0.0264
Epoch 793/800
24/24 [==============================] - 0s 230us/step - loss: 0.0264
Epoch 794/800
24/24 [==============================] - 0s 254us/step - loss: 0.0259
Epoch 795/800
24/24 [==============================] - 0s 277us/step - loss: 0.0260
Epoch 796/800
24/24 [==============================] - 0s 219us/step - loss: 0.0260
Epoch 797/800
24/24 [==============================] - 0s 239us/step - loss: 0.0258
Epoch 798/800
24/24 [==============================] - 0s 232us/step - loss: 0.0261
Epoch 799/800
24/24 [==============================] - 0s 239us/step - loss: 0.0258
Epoch 800/800
24/24 [==============================] - 0s 195us/step - loss: 0.0258
best epoch =  775
smallest loss = 0.025612175464630127
```

In [429…

```
# Task 1.2 Part e
from sklearn import metrics

# This line of code can be used to reconstruct the saved model. The name of t
recon_model = keras.models.load_model("best_model")

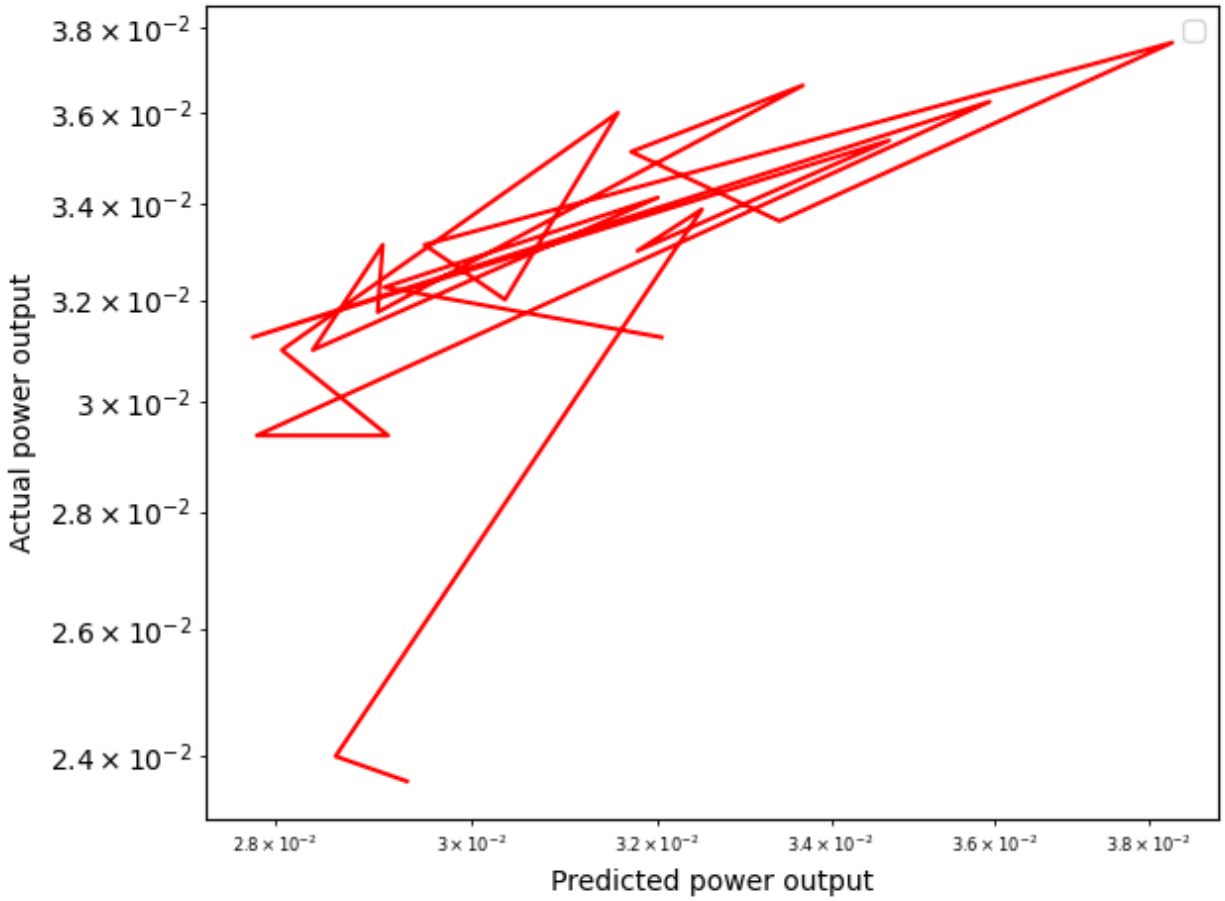
import matplotlib.pyplot as plt

y_predict = []
Wdotpred = []
Wdotorig = []

for i in range(len(X_trainn)):
    test = [[X_trainn[i][0], X_trainn[i][1], X_trainn[i][2]]]
    testarray = np.array(test)
    a3 = recon_model.predict(testarray)
    y_predict.append([a3[0][0], a3[0][1]])
    Wdotpred.append([a3[0][1]])
    Wdotorig.append([y_trainn[i][1]])

plt.figure()
plt.loglog(Wdotpred, Wdotorig, c='r')
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpred,Wdotorig)
mae_Vl = metrics.mean_absolute_error(y_predict[:][1],y_trainn[:][1])
print('mean absolute error between predictions and the collection of test dat
```




```
No handles with labels found to put in legend.
mean absolute error between predictions and the collection of test data: Vl =
0.20995893429219725  Wdot =  0.0023914916813373576
```

In [390…

```
# Task 1.2 Part f

# This line of code can be used to reconstruct the saved model. The name of t
recon_model = keras.models.load_model("best_model")

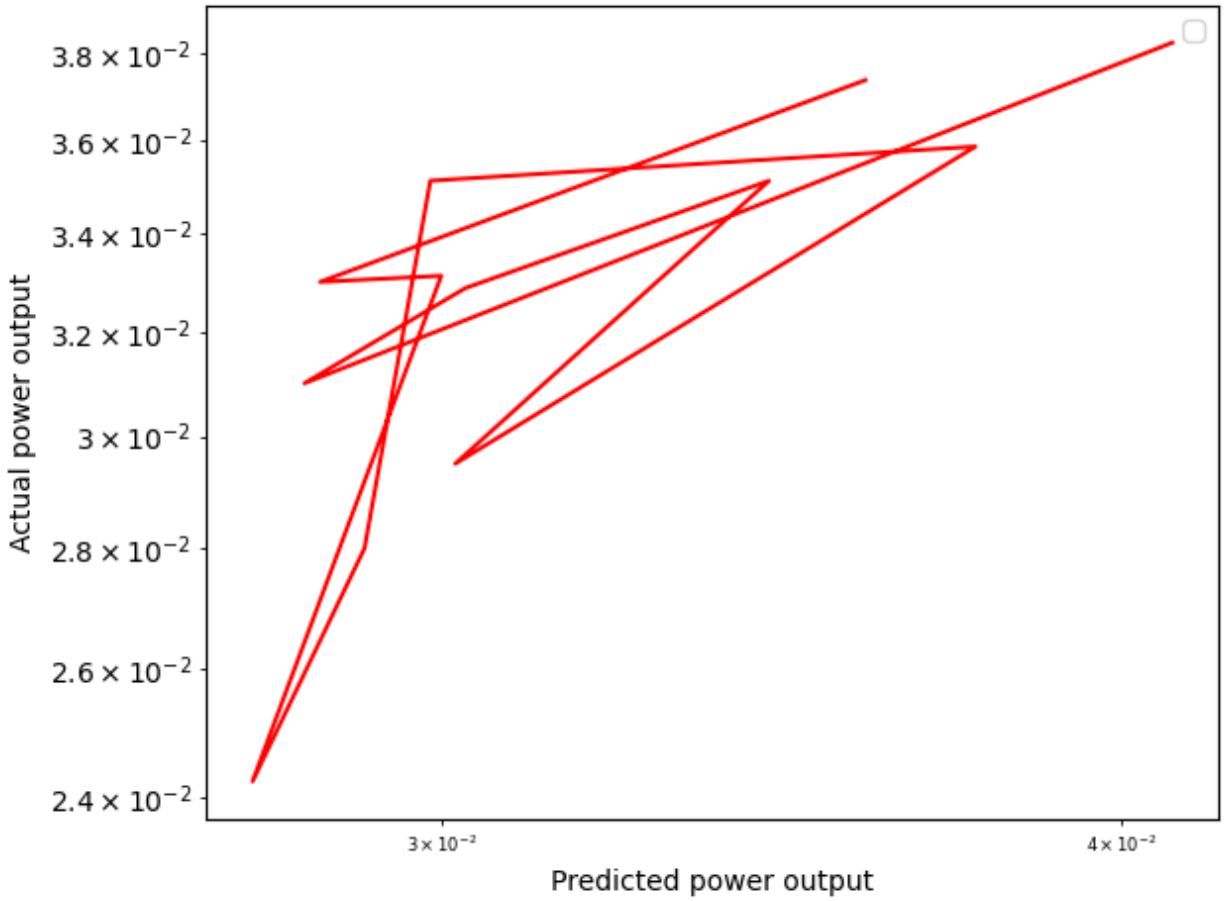
import matplotlib.pyplot as plt

y_predictn = []
y_traino = []
Wdotpred2 = []
Wdotorig2 = []

for i in range(len(X_testn)):
    testn = [[X_testn[i][0], X_testn[i][1], X_testn[i][2]]]
    testarrayn = np.array(testn)
    a3 = recon_model.predict(testarrayn)
    y_predictn.append([a3[0][0], a3[0][1]])
    Wdotpred2.append([a3[0][1]])
    y_traino.append([y_testn[i][0], y_testn[i][1]])
    Wdotorig2.append([y_testn[i][1]])

plt.figure()
plt.loglog(Wdotpred2, Wdotorig2, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpred2,Wdotorig2)
mae_Vl = metrics.mean_absolute_error(y_predictn[:][1],y_traino[:][1])
print('mean absolute error between predictions and the collection of test dat
```




```
No handles with labels found to put in legend.
mean absolute error between predictions and the collection of test data: Vl =
0.032343255385756484  Wdot =  0.002482627061506114
```

In [17]:

```
#Task1.2 Part g

#Part 1 input HI FLUX DATA: Air temp (degC), ID (W/sqm), load resistance (ohm

xdata = [[-10.0, 1550, 4.464],
  [-10.0, 1850, 4.464],
  [10.0, 1550, 4.464],
  [10.0, 1850, 4.464],
  [30.0, 1550, 4.464],
  [30.0, 1850, 4.464],
  [-10.0, 1550, 6.696],
  [-10.0, 1850, 6.696],
  [10.0, 1550, 6.696],
  [10.0, 1850, 6.696],
  [30.0, 1550, 6.696],
  [30.0, 1850, 6.696],
  [-10.0, 1550, 8.928],
  [-10.0, 1850, 8.928],
  [10.0, 1550, 8.928],
```

```
  [10.0, 1850, 8.928],
  [30.0, 1550, 8.928],
  [30.0, 1850, 8.928]]

#Part 1 output HI FLUX DATA: load voltage (V) and Power out (W)
ydata = [[26.1, 152.8],
 [26.5, 157.4],
 [27.9, 174.5],
 [28.3, 179.9],
 [29.6, 197.5],
 [30.1, 203.88396644646863],
 [26.9, 108.3334196813148],
 [27.2, 111.25283762284167],
 [28.8, 123.90621088656334],
 [29.1, 127.3006573252854],
 [30.6, 140.4799701696024],
 [31.0, 144.39313467349314],
 [27.3, 83.77924895974105],
 [27.6, 85.91711375810277],
 [29.2, 95.88391097375488],
 [29.6, 98.3599961391009],
 [31.1, 108.78119217392532],
 [31.5, 111.62434462334976]]


xarray= numpy.array(xdata)
yarray= numpy.array(ydata)

Vlh = []
Wdoth = []
Tairh =[]
Idh =[]
Rlh =[]

for x in range(len(xarray)):
    Tairh.append(xarray[x][0])
    Idh.append(xarray[x][1])
    Rlh.append(xarray[x][2])

for y in range(len(yarray)):
    Vlh.append(xarray[y][0])
    Wdoth.append(xarray[y][1])

medTairh = median(Tairh)
medIdh = median(Idh)
medRlh = median(Rlh)
medVlh = median(Vlh)
medWdoth = median(Wdoth)

Tairhn = Tairh/medTairh
Idhn = Idh/medIdh
Rlhn = Rlh/medRlh
Vlhn = Vlh/medVlh
```

```
Wdothn = Wdoth/medWdoth

xarrayhn = np.column_stack((Tairhn, Idhn, Rlhn))
yarrayhn = np.column_stack((Vlhn, Wdothn))

print(xarrayhn)
print(yarrayhn)
```

```
[[-1.          0.91176471  0.66666667]
 [-1.          1.08823529  0.66666667]
 [ 1.          0.91176471  0.66666667]
 [ 1.          1.08823529  0.66666667]
 [ 3.          0.91176471  0.66666667]
 [ 3.          1.08823529  0.66666667]
 [-1.          0.91176471  1.        ]
 [-1.          1.08823529  1.        ]
 [ 1.          0.91176471  1.        ]
 [ 1.          1.08823529  1.        ]
 [ 3.          0.91176471  1.        ]
 [ 3.          1.08823529  1.        ]
 [-1.          0.91176471  1.33333333]
 [-1.          1.08823529  1.33333333]
 [ 1.          0.91176471  1.33333333]
 [ 1.          1.08823529  1.33333333]
 [ 3.          0.91176471  1.33333333]
 [ 3.          1.08823529  1.33333333]]
[[-1.          0.91176471]
 [-1.          1.08823529]
 [ 1.          0.91176471]
 [ 1.          1.08823529]
 [ 3.          0.91176471]
 [ 3.          1.08823529]
 [-1.          0.91176471]
 [-1.          1.08823529]
 [ 1.          0.91176471]
 [ 1.          1.08823529]
 [ 3.          0.91176471]
 [ 3.          1.08823529]
 [-1.          0.91176471]
 [-1.          1.08823529]
 [ 1.          0.91176471]
 [ 1.          1.08823529]
 [ 3.          0.91176471]
 [ 3.          1.08823529]]
```

In [393…

```
# Task 1.2 Part g

# This line of code can be used to reconstruct the saved model. The name of t
recon_model = keras.models.load_model("best_model")

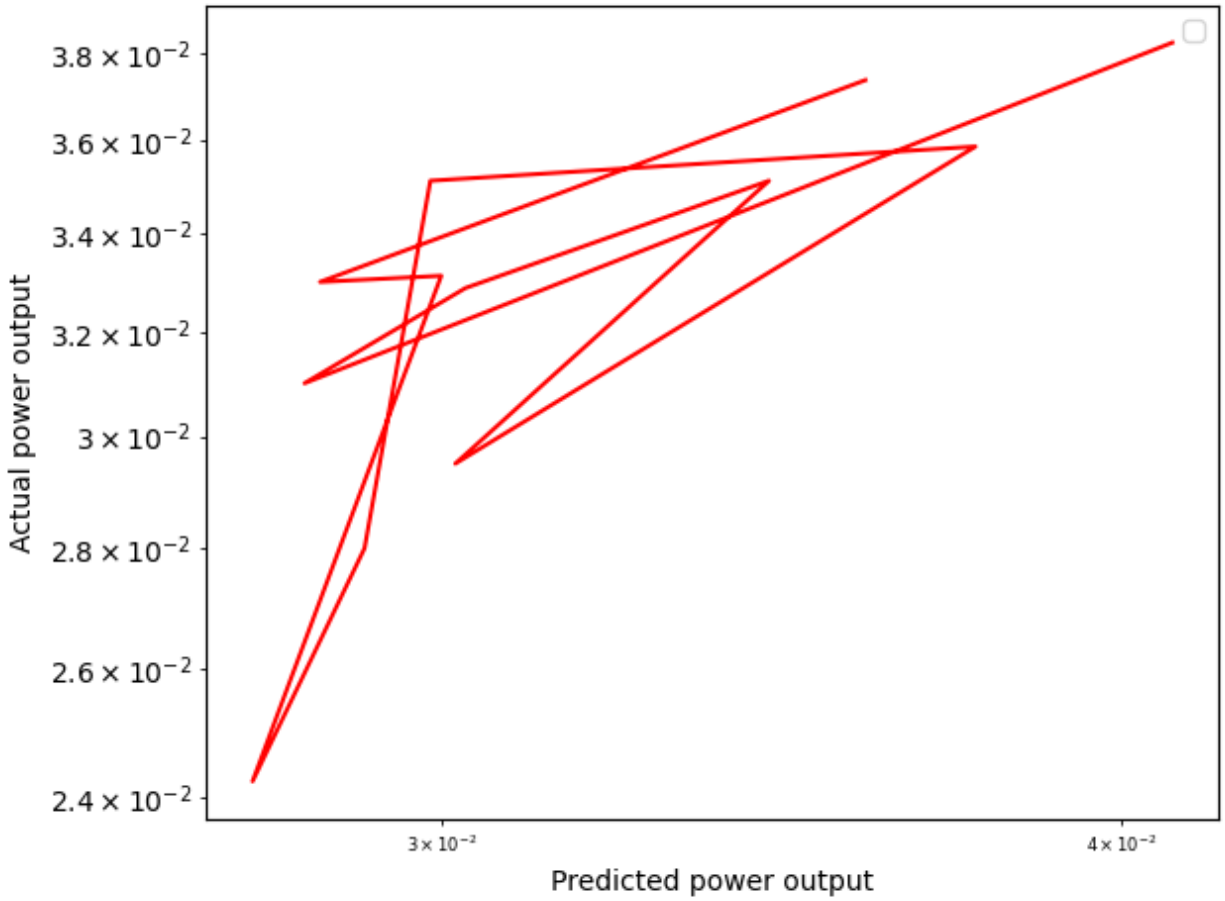
import matplotlib.pyplot as plt

y_predicthn = []
y_train = []
Wdotpredh = []
Wdotorigh = []

for i in range(len(xarrayhn)):
    testhn = [[xarrayhn[i][0], xarrayhn[i][1], xarrayhn[i][2]]]
    testarrayhn = np.array(testhn)
    a3 = recon_model.predict(testarrayhn)
    y_predicthn.append([a3[0][0], a3[0][1]])
    Wdotpredh.append([a3[0][1]])
    y_train.append([yarrayhn[i][0], yarrayhn[i][1]])
    Wdotorigh.append([yarrayhn[i][1]])

plt.figure()
plt.loglog(Wdotpred2, Wdotorig2, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpredh,Wdotorigh)
mae_Vl = metrics.mean_absolute_error(y_predicthn[:][1],y_train[:][1])
print('mean absolute error between predictions and the collection of test dat
```




```
No handles with labels found to put in legend.
mean absolute error between predictions and the collection of test data: Vl =
2.244589985183933  Wdot =  0.9696147735748026
```

In [394…

```
#Task1.2 part h
import matplotlib.pyplot as plt
import numpy as np

fig = plt.figure()
ax = plt.axes(projection='3d')

X = np.linspace(500, 1800) #Id
Y = np.linspace(4, 8) #Rl
Zp = []
Xp = []
Yp = []
Tair = 20
testdata = []

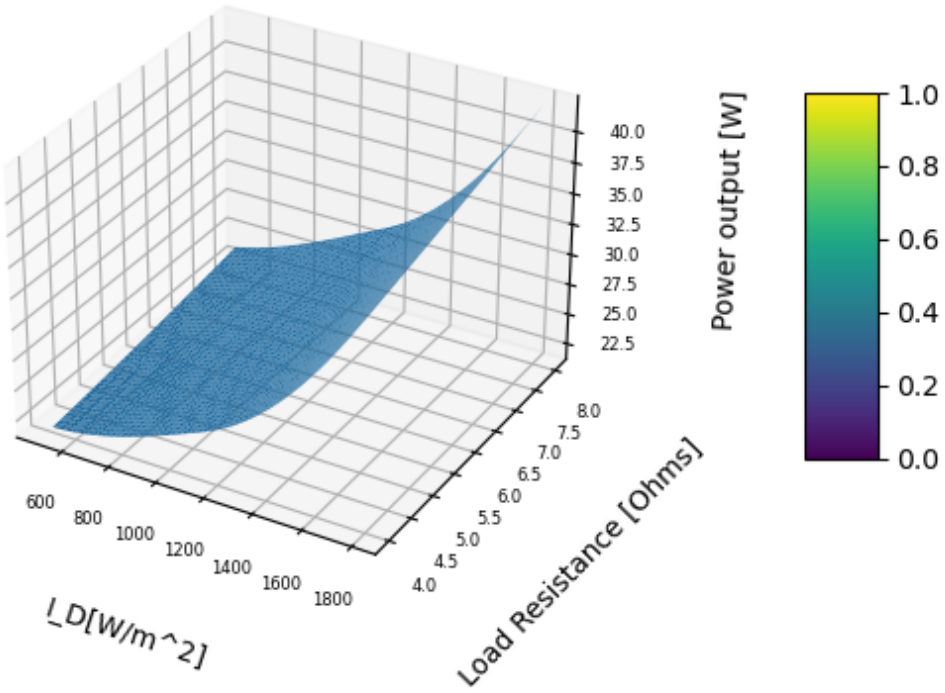
Tn = Tair/medTair
Xn = X/medId
Yn = Y/medRl

for x in range(len(Xn)):
    for y in range(len(Yn)):
        testdata.append([Tn, Xn[x], Yn[y]])
        Xp.append(Xn[x]*medId)
        Yp.append(Yn[y]*medRl)

for x in range(len(testdata)):
    test = [[testdata[x][0], testdata[x][1], testdata[x][2]]]
    testarray = np.array(test)
    outptn = recon_model.predict(testarray)
    Zp.append(outptn[0][1]*medWdot)

surf = ax.plot_trisurf(Xp, Yp, Zp)
fig.colorbar(surf, shrink=0.5, aspect=5, pad=0.2)
ax.set_zlabel('Power output [W]', rotation=60)
ax.set_ylabel('Load Resistance [Ohms]')
ax.set_xlabel('I_D[W/m^2]', rotation=150)
ax.xaxis.labelpad=15
ax.yaxis.labelpad=15
ax.zaxis.labelpad=15

plt.show()
```



In [18]:

```
#Task 1.3
# define neural network model

from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

model2 = keras.Sequential([
    keras.layers.Dense(6, activation=K.elu, input_shape=[3],  kernel_initiali
    keras.layers.Dense(8, activation=K.elu,  kernel_initializer=initializer),
    keras.layers.Dense(12, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(16,  activation=K.elu, kernel_initializer=initializer)
    keras.layers.Dense(8,  activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(2, kernel_initializer=initializer)
  ])
```

In [25]:

```
#from tf.keras import optimizers
rms = keras.optimizers.RMSprop(0.0003)
model2.compile(loss='mean_absolute_error',optimizer=rms)
```

In [26]:

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 80,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model2.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = model2.fit(X_trainn,y_trainn,epochs=800,callbacks=[es])

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))

model2.save('./best_model2')
```

```
Epoch 1/800
24/24 [==============================] - 2s 98ms/step - loss: 0.0718
Epoch 2/800
24/24 [==============================] - 0s 218us/step - loss: 0.0473
Epoch 3/800
24/24 [==============================] - 0s 275us/step - loss: 0.0371
Epoch 4/800
24/24 [==============================] - 0s 247us/step - loss: 0.0340
Epoch 5/800
24/24 [==============================] - 0s 398us/step - loss: 0.0334
Epoch 6/800
24/24 [==============================] - 0s 378us/step - loss: 0.0331
Epoch 7/800
24/24 [==============================] - 0s 566us/step - loss: 0.0328
Epoch 8/800
24/24 [==============================] - 0s 417us/step - loss: 0.0326
Epoch 9/800
24/24 [==============================] - 0s 308us/step - loss: 0.0325
Epoch 10/800
24/24 [==============================] - 0s 580us/step - loss: 0.0324
Epoch 11/800
24/24 [==============================] - 0s 308us/step - loss: 0.0325
Epoch 12/800
24/24 [==============================] - 0s 652us/step - loss: 0.0322
Epoch 13/800
24/24 [==============================] - 0s 685us/step - loss: 0.0325
Epoch 14/800
24/24 [==============================] - 0s 470us/step - loss: 0.0327
Epoch 15/800
24/24 [==============================] - 0s 697us/step - loss: 0.0324
Epoch 16/800
24/24 [==============================] - 0s 998us/step - loss: 0.0321
Epoch 17/800
```

```
24/24 [==============================] - 0s 204us/step - loss: 0.0321
Epoch 18/800
24/24 [==============================] - 0s 249us/step - loss: 0.0323
Epoch 19/800
24/24 [==============================] - 0s 246us/step - loss: 0.0321
Epoch 20/800
24/24 [==============================] - 0s 270us/step - loss: 0.0333
Epoch 21/800
24/24 [==============================] - 0s 231us/step - loss: 0.0333
Epoch 22/800
24/24 [==============================] - 0s 211us/step - loss: 0.0328
Epoch 23/800
24/24 [==============================] - 0s 200us/step - loss: 0.0323
Epoch 24/800
24/24 [==============================] - 0s 223us/step - loss: 0.0322
Epoch 25/800
24/24 [==============================] - 0s 207us/step - loss: 0.0321
Epoch 26/800
24/24 [==============================] - 0s 256us/step - loss: 0.0317
Epoch 27/800
24/24 [==============================] - 0s 197us/step - loss: 0.0322
Epoch 28/800
24/24 [==============================] - 0s 265us/step - loss: 0.0330
Epoch 29/800
24/24 [==============================] - 0s 266us/step - loss: 0.0324
Epoch 30/800
24/24 [==============================] - 0s 281us/step - loss: 0.0317
Epoch 31/800
24/24 [==============================] - 0s 310us/step - loss: 0.0321
Epoch 32/800
24/24 [==============================] - 0s 249us/step - loss: 0.0323
Epoch 33/800
24/24 [==============================] - 0s 290us/step - loss: 0.0321
Epoch 34/800
24/24 [==============================] - 0s 333us/step - loss: 0.0317
Epoch 35/800
24/24 [==============================] - 0s 326us/step - loss: 0.0319
Epoch 36/800
24/24 [==============================] - 0s 265us/step - loss: 0.0321
Epoch 37/800
24/24 [==============================] - 0s 198us/step - loss: 0.0325
Epoch 38/800
24/24 [==============================] - 0s 266us/step - loss: 0.0317
Epoch 39/800
24/24 [==============================] - 0s 242us/step - loss: 0.0314
Epoch 40/800
24/24 [==============================] - 0s 210us/step - loss: 0.0318
Epoch 41/800
24/24 [==============================] - 0s 242us/step - loss: 0.0321
Epoch 42/800
24/24 [==============================] - 0s 238us/step - loss: 0.0314
Epoch 43/800
24/24 [==============================] - 0s 401us/step - loss: 0.0316
Epoch 44/800
24/24 [==============================] - 0s 401us/step - loss: 0.0314
Epoch 45/800
24/24 [==============================] - 0s 651us/step - loss: 0.0317
```

```
Epoch 46/800
24/24 [==============================] - 0s 417us/step - loss: 0.0323
Epoch 47/800
24/24 [==============================] - 0s 342us/step - loss: 0.0325
Epoch 48/800
24/24 [==============================] - 0s 268us/step - loss: 0.0312
Epoch 49/800
24/24 [==============================] - 0s 206us/step - loss: 0.0311
Epoch 50/800
24/24 [==============================] - 0s 205us/step - loss: 0.0315
Epoch 51/800
24/24 [==============================] - 0s 237us/step - loss: 0.0322
Epoch 52/800
24/24 [==============================] - 0s 299us/step - loss: 0.0322
Epoch 53/800
24/24 [==============================] - 0s 251us/step - loss: 0.0311
Epoch 54/800
24/24 [==============================] - 0s 373us/step - loss: 0.0311
Epoch 55/800
24/24 [==============================] - 0s 353us/step - loss: 0.0313
Epoch 56/800
24/24 [==============================] - 0s 189us/step - loss: 0.0317
Epoch 57/800
24/24 [==============================] - 0s 235us/step - loss: 0.0316
Epoch 58/800
24/24 [==============================] - 0s 282us/step - loss: 0.0311
Epoch 59/800
24/24 [==============================] - 0s 234us/step - loss: 0.0311
Epoch 60/800
24/24 [==============================] - 0s 239us/step - loss: 0.0311
Epoch 61/800
24/24 [==============================] - 0s 289us/step - loss: 0.0308
Epoch 62/800
24/24 [==============================] - 0s 180us/step - loss: 0.0311
Epoch 63/800
24/24 [==============================] - 0s 280us/step - loss: 0.0313
Epoch 64/800
24/24 [==============================] - 0s 217us/step - loss: 0.0328
Epoch 65/800
24/24 [==============================] - 0s 234us/step - loss: 0.0320
Epoch 66/800
24/24 [==============================] - 0s 225us/step - loss: 0.0308
Epoch 67/800
24/24 [==============================] - 0s 204us/step - loss: 0.0308
Epoch 68/800
24/24 [==============================] - 0s 228us/step - loss: 0.0309
Epoch 69/800
24/24 [==============================] - 0s 325us/step - loss: 0.0312
Epoch 70/800
24/24 [==============================] - 0s 384us/step - loss: 0.0309
Epoch 71/800
24/24 [==============================] - 0s 304us/step - loss: 0.0317
Epoch 72/800
24/24 [==============================] - 0s 220us/step - loss: 0.0312
Epoch 73/800
24/24 [==============================] - 0s 419us/step - loss: 0.0309
Epoch 74/800
```

```
24/24 [==============================] - 0s 274us/step - loss: 0.0308
Epoch 75/800
24/24 [==============================] - 0s 233us/step - loss: 0.0310
Epoch 76/800
24/24 [==============================] - 0s 209us/step - loss: 0.0308
Epoch 77/800
24/24 [==============================] - 0s 211us/step - loss: 0.0308
Epoch 78/800
24/24 [==============================] - 0s 216us/step - loss: 0.0306
Epoch 79/800
24/24 [==============================] - 0s 207us/step - loss: 0.0311
Epoch 80/800
24/24 [==============================] - 0s 208us/step - loss: 0.0313
Epoch 81/800
24/24 [==============================] - 0s 271us/step - loss: 0.0314
Epoch 82/800
24/24 [==============================] - 0s 220us/step - loss: 0.0306
Epoch 83/800
24/24 [==============================] - 0s 383us/step - loss: 0.0305
Epoch 84/800
24/24 [==============================] - 0s 245us/step - loss: 0.0303
Epoch 85/800
24/24 [==============================] - 0s 223us/step - loss: 0.0302
Epoch 86/800
24/24 [==============================] - 0s 180us/step - loss: 0.0301
Epoch 87/800
24/24 [==============================] - 0s 194us/step - loss: 0.0302
Epoch 88/800
24/24 [==============================] - 0s 238us/step - loss: 0.0309
Epoch 89/800
24/24 [==============================] - 0s 233us/step - loss: 0.0307
Epoch 90/800
24/24 [==============================] - 0s 248us/step - loss: 0.0305
Epoch 91/800
24/24 [==============================] - 0s 208us/step - loss: 0.0315
Epoch 92/800
24/24 [==============================] - 0s 229us/step - loss: 0.0315
Epoch 93/800
24/24 [==============================] - 0s 196us/step - loss: 0.0312
Epoch 94/800
24/24 [==============================] - 0s 194us/step - loss: 0.0301
Epoch 95/800
24/24 [==============================] - 0s 199us/step - loss: 0.0300
Epoch 96/800
24/24 [==============================] - 0s 176us/step - loss: 0.0300
Epoch 97/800
24/24 [==============================] - 0s 213us/step - loss: 0.0299
Epoch 98/800
24/24 [==============================] - 0s 459us/step - loss: 0.0298
Epoch 99/800
24/24 [==============================] - 0s 233us/step - loss: 0.0298
Epoch 100/800
24/24 [==============================] - 0s 211us/step - loss: 0.0297
Epoch 101/800
24/24 [==============================] - 0s 218us/step - loss: 0.0301
Epoch 102/800
24/24 [==============================] - 0s 250us/step - loss: 0.0308
```

```
Epoch 103/800
24/24 [==============================] - 0s 225us/step - loss: 0.0311
Epoch 104/800
24/24 [==============================] - 0s 242us/step - loss: 0.0309
Epoch 105/800
24/24 [==============================] - 0s 290us/step - loss: 0.0300
Epoch 106/800
24/24 [==============================] - 0s 231us/step - loss: 0.0301
Epoch 107/800
24/24 [==============================] - 0s 271us/step - loss: 0.0297
Epoch 108/800
24/24 [==============================] - 0s 219us/step - loss: 0.0296
Epoch 109/800
24/24 [==============================] - 0s 270us/step - loss: 0.0295
Epoch 110/800
24/24 [==============================] - 0s 372us/step - loss: 0.0295
Epoch 111/800
24/24 [==============================] - 0s 259us/step - loss: 0.0297
Epoch 112/800
24/24 [==============================] - 0s 216us/step - loss: 0.0296
Epoch 113/800
24/24 [==============================] - 0s 359us/step - loss: 0.0308
Epoch 114/800
24/24 [==============================] - 0s 276us/step - loss: 0.0309
Epoch 115/800
24/24 [==============================] - 0s 393us/step - loss: 0.0296
Epoch 116/800
24/24 [==============================] - 0s 299us/step - loss: 0.0298
Epoch 117/800
24/24 [==============================] - 0s 375us/step - loss: 0.0297
Epoch 118/800
24/24 [==============================] - 0s 369us/step - loss: 0.0294
Epoch 119/800
24/24 [==============================] - 0s 362us/step - loss: 0.0293
Epoch 120/800
24/24 [==============================] - 0s 223us/step - loss: 0.0293
Epoch 121/800
24/24 [==============================] - 0s 397us/step - loss: 0.0303
Epoch 122/800
24/24 [==============================] - 0s 327us/step - loss: 0.0309
Epoch 123/800
24/24 [==============================] - 0s 379us/step - loss: 0.0298
Epoch 124/800
24/24 [==============================] - 0s 385us/step - loss: 0.0297
Epoch 125/800
24/24 [==============================] - 0s 271us/step - loss: 0.0292
Epoch 126/800
24/24 [==============================] - 0s 264us/step - loss: 0.0292
Epoch 127/800
24/24 [==============================] - 0s 264us/step - loss: 0.0290
Epoch 128/800
24/24 [==============================] - 0s 300us/step - loss: 0.0289
Epoch 129/800
24/24 [==============================] - 0s 429us/step - loss: 0.0288
Epoch 130/800
24/24 [==============================] - 0s 254us/step - loss: 0.0287
Epoch 131/800
```

```
24/24 [==============================] - 0s 282us/step - loss: 0.0290
Epoch 132/800
24/24 [==============================] - 0s 449us/step - loss: 0.0293
Epoch 133/800
24/24 [==============================] - 0s 368us/step - loss: 0.0302
Epoch 134/800
24/24 [==============================] - 0s 332us/step - loss: 0.0303
Epoch 135/800
24/24 [==============================] - 0s 384us/step - loss: 0.0289
Epoch 136/800
24/24 [==============================] - 0s 384us/step - loss: 0.0287
Epoch 137/800
24/24 [==============================] - 0s 425us/step - loss: 0.0287
Epoch 138/800
24/24 [==============================] - 0s 418us/step - loss: 0.0285
Epoch 139/800
24/24 [==============================] - 0s 417us/step - loss: 0.0285
Epoch 140/800
24/24 [==============================] - 0s 403us/step - loss: 0.0284
Epoch 141/800
24/24 [==============================] - 0s 282us/step - loss: 0.0284
Epoch 142/800
24/24 [==============================] - 0s 427us/step - loss: 0.0283
Epoch 143/800
24/24 [==============================] - 0s 467us/step - loss: 0.0285
Epoch 144/800
24/24 [==============================] - 0s 657us/step - loss: 0.0285
Epoch 145/800
24/24 [==============================] - 0s 314us/step - loss: 0.0283
Epoch 146/800
24/24 [==============================] - 0s 351us/step - loss: 0.0283
Epoch 147/800
24/24 [==============================] - 0s 349us/step - loss: 0.0283
Epoch 148/800
24/24 [==============================] - 0s 457us/step - loss: 0.0288
Epoch 149/800
24/24 [==============================] - 0s 380us/step - loss: 0.0297
Epoch 150/800
24/24 [==============================] - 0s 298us/step - loss: 0.0300
Epoch 151/800
24/24 [==============================] - 0s 473us/step - loss: 0.0306
Epoch 152/800
24/24 [==============================] - 0s 346us/step - loss: 0.0286
Epoch 153/800
24/24 [==============================] - 0s 223us/step - loss: 0.0282
Epoch 154/800
24/24 [==============================] - 0s 204us/step - loss: 0.0280
Epoch 155/800
24/24 [==============================] - 0s 258us/step - loss: 0.0279
Epoch 156/800
24/24 [==============================] - 0s 270us/step - loss: 0.0279
Epoch 157/800
24/24 [==============================] - 0s 229us/step - loss: 0.0278
Epoch 158/800
24/24 [==============================] - 0s 216us/step - loss: 0.0278
Epoch 159/800
24/24 [==============================] - 0s 479us/step - loss: 0.0277
```

```
Epoch 160/800
24/24 [==============================] - 0s 205us/step - loss: 0.0278
Epoch 161/800
24/24 [==============================] - 0s 304us/step - loss: 0.0276
Epoch 162/800
24/24 [==============================] - 0s 589us/step - loss: 0.0275
Epoch 163/800
24/24 [==============================] - 0s 944us/step - loss: 0.0275
Epoch 164/800
24/24 [==============================] - 0s 369us/step - loss: 0.0278
Epoch 165/800
24/24 [==============================] - 0s 472us/step - loss: 0.0304
Epoch 166/800
24/24 [==============================] - 0s 506us/step - loss: 0.0293
Epoch 167/800
24/24 [==============================] - 0s 238us/step - loss: 0.0289
Epoch 168/800
24/24 [==============================] - 0s 789us/step - loss: 0.0276
Epoch 169/800
24/24 [==============================] - 0s 291us/step - loss: 0.0275
Epoch 170/800
24/24 [==============================] - 0s 179us/step - loss: 0.0274
Epoch 171/800
24/24 [==============================] - 0s 220us/step - loss: 0.0273
Epoch 172/800
24/24 [==============================] - 0s 194us/step - loss: 0.0272
Epoch 173/800
24/24 [==============================] - 0s 222us/step - loss: 0.0271
Epoch 174/800
24/24 [==============================] - 0s 194us/step - loss: 0.0277
Epoch 175/800
24/24 [==============================] - 0s 198us/step - loss: 0.0285
Epoch 176/800
24/24 [==============================] - 0s 311us/step - loss: 0.0276
Epoch 177/800
24/24 [==============================] - 0s 207us/step - loss: 0.0274
Epoch 178/800
24/24 [==============================] - 0s 280us/step - loss: 0.0277
Epoch 179/800
24/24 [==============================] - 0s 467us/step - loss: 0.0280
Epoch 180/800
24/24 [==============================] - 0s 528us/step - loss: 0.0278
Epoch 181/800
24/24 [==============================] - 0s 229us/step - loss: 0.0278
Epoch 182/800
24/24 [==============================] - 0s 273us/step - loss: 0.0274
Epoch 183/800
24/24 [==============================] - 0s 228us/step - loss: 0.0272
Epoch 184/800
24/24 [==============================] - 0s 207us/step - loss: 0.0269
Epoch 185/800
24/24 [==============================] - 0s 174us/step - loss: 0.0268
Epoch 186/800
24/24 [==============================] - 0s 163us/step - loss: 0.0271
Epoch 187/800
24/24 [==============================] - 0s 202us/step - loss: 0.0267
Epoch 188/800
```

```
24/24 [==============================] - 0s 189us/step - loss: 0.0273
Epoch 189/800
24/24 [==============================] - 0s 208us/step - loss: 0.0283
Epoch 190/800
24/24 [==============================] - 0s 214us/step - loss: 0.0273
Epoch 191/800
24/24 [==============================] - 0s 238us/step - loss: 0.0274
Epoch 192/800
24/24 [==============================] - 0s 256us/step - loss: 0.0275
Epoch 193/800
24/24 [==============================] - 0s 494us/step - loss: 0.0274
Epoch 194/800
24/24 [==============================] - 0s 683us/step - loss: 0.0274
Epoch 195/800
24/24 [==============================] - 0s 531us/step - loss: 0.0268
Epoch 196/800
24/24 [==============================] - 0s 669us/step - loss: 0.0267
Epoch 197/800
24/24 [==============================] - 0s 359us/step - loss: 0.0267
Epoch 198/800
24/24 [==============================] - 0s 539us/step - loss: 0.0265
Epoch 199/800
24/24 [==============================] - 0s 479us/step - loss: 0.0265
Epoch 200/800
24/24 [==============================] - 0s 289us/step - loss: 0.0266
Epoch 201/800
24/24 [==============================] - 0s 537us/step - loss: 0.0265
Epoch 202/800
24/24 [==============================] - 0s 187us/step - loss: 0.0266
Epoch 203/800
24/24 [==============================] - 0s 274us/step - loss: 0.0263
Epoch 204/800
24/24 [==============================] - 0s 196us/step - loss: 0.0264
Epoch 205/800
24/24 [==============================] - 0s 215us/step - loss: 0.0264
Epoch 206/800
24/24 [==============================] - 0s 210us/step - loss: 0.0265
Epoch 207/800
24/24 [==============================] - 0s 176us/step - loss: 0.0261
Epoch 208/800
24/24 [==============================] - 0s 182us/step - loss: 0.0261
Epoch 209/800
24/24 [==============================] - 0s 235us/step - loss: 0.0266
Epoch 210/800
24/24 [==============================] - 0s 193us/step - loss: 0.0272
Epoch 211/800
24/24 [==============================] - 0s 240us/step - loss: 0.0277
Epoch 212/800
24/24 [==============================] - 0s 240us/step - loss: 0.0272
Epoch 213/800
24/24 [==============================] - 0s 429us/step - loss: 0.0281
Epoch 214/800
24/24 [==============================] - 0s 239us/step - loss: 0.0292
Epoch 215/800
24/24 [==============================] - 0s 313us/step - loss: 0.0267
Epoch 216/800
24/24 [==============================] - 0s 280us/step - loss: 0.0263
```

```
Epoch 217/800
24/24 [==============================] - 0s 331us/step - loss: 0.0260
Epoch 218/800
24/24 [==============================] - 0s 238us/step - loss: 0.0258
Epoch 219/800
24/24 [==============================] - 0s 240us/step - loss: 0.0258
Epoch 220/800
24/24 [==============================] - 0s 226us/step - loss: 0.0262
Epoch 221/800
24/24 [==============================] - 0s 201us/step - loss: 0.0257
Epoch 222/800
24/24 [==============================] - 0s 254us/step - loss: 0.0256
Epoch 223/800
24/24 [==============================] - 0s 253us/step - loss: 0.0263
Epoch 224/800
24/24 [==============================] - 0s 260us/step - loss: 0.0256
Epoch 225/800
24/24 [==============================] - 0s 271us/step - loss: 0.0255
Epoch 226/800
24/24 [==============================] - 0s 254us/step - loss: 0.0257
Epoch 227/800
24/24 [==============================] - 0s 281us/step - loss: 0.0258
Epoch 228/800
24/24 [==============================] - 0s 283us/step - loss: 0.0258
Epoch 229/800
24/24 [==============================] - 0s 338us/step - loss: 0.0255
Epoch 230/800
24/24 [==============================] - 0s 270us/step - loss: 0.0262
Epoch 231/800
24/24 [==============================] - 0s 279us/step - loss: 0.0278
Epoch 232/800
24/24 [==============================] - 0s 226us/step - loss: 0.0271
Epoch 233/800
24/24 [==============================] - 0s 216us/step - loss: 0.0263
Epoch 234/800
24/24 [==============================] - 0s 208us/step - loss: 0.0258
Epoch 235/800
24/24 [==============================] - 0s 250us/step - loss: 0.0257
Epoch 236/800
24/24 [==============================] - 0s 305us/step - loss: 0.0258
Epoch 237/800
24/24 [==============================] - 0s 218us/step - loss: 0.0254
Epoch 238/800
24/24 [==============================] - 0s 236us/step - loss: 0.0254
Epoch 239/800
24/24 [==============================] - 0s 192us/step - loss: 0.0253
Epoch 240/800
24/24 [==============================] - 0s 186us/step - loss: 0.0253
Epoch 241/800
24/24 [==============================] - 0s 201us/step - loss: 0.0251
Epoch 242/800
24/24 [==============================] - 0s 186us/step - loss: 0.0253
Epoch 243/800
24/24 [==============================] - 0s 234us/step - loss: 0.0251
Epoch 244/800
24/24 [==============================] - 0s 196us/step - loss: 0.0252
Epoch 245/800
```

```
24/24 [==============================] - 0s 233us/step - loss: 0.0256
Epoch 246/800
24/24 [==============================] - 0s 231us/step - loss: 0.0259
Epoch 247/800
24/24 [==============================] - 0s 231us/step - loss: 0.0275
Epoch 248/800
24/24 [==============================] - 0s 208us/step - loss: 0.0265
Epoch 249/800
24/24 [==============================] - 0s 222us/step - loss: 0.0262
Epoch 250/800
24/24 [==============================] - 0s 211us/step - loss: 0.0256
Epoch 251/800
24/24 [==============================] - 0s 200us/step - loss: 0.0252
Epoch 252/800
24/24 [==============================] - 0s 213us/step - loss: 0.0249
Epoch 253/800
24/24 [==============================] - 0s 170us/step - loss: 0.0247
Epoch 254/800
24/24 [==============================] - 0s 204us/step - loss: 0.0247
Epoch 255/800
24/24 [==============================] - 0s 209us/step - loss: 0.0247
Epoch 256/800
24/24 [==============================] - 0s 233us/step - loss: 0.0247
Epoch 257/800
24/24 [==============================] - 0s 196us/step - loss: 0.0245
Epoch 258/800
24/24 [==============================] - 0s 186us/step - loss: 0.0246
Epoch 259/800
24/24 [==============================] - 0s 278us/step - loss: 0.0246
Epoch 260/800
24/24 [==============================] - 0s 228us/step - loss: 0.0245
Epoch 261/800
24/24 [==============================] - 0s 529us/step - loss: 0.0244
Epoch 262/800
24/24 [==============================] - 0s 245us/step - loss: 0.0261
Epoch 263/800
24/24 [==============================] - 0s 254us/step - loss: 0.0290
Epoch 264/800
24/24 [==============================] - 0s 220us/step - loss: 0.0255
Epoch 265/800
24/24 [==============================] - 0s 295us/step - loss: 0.0249
Epoch 266/800
24/24 [==============================] - 0s 237us/step - loss: 0.0244
Epoch 267/800
24/24 [==============================] - 0s 236us/step - loss: 0.0242
Epoch 268/800
24/24 [==============================] - 0s 223us/step - loss: 0.0243
Epoch 269/800
24/24 [==============================] - 0s 214us/step - loss: 0.0241
Epoch 270/800
24/24 [==============================] - 0s 250us/step - loss: 0.0241
Epoch 271/800
24/24 [==============================] - 0s 326us/step - loss: 0.0241
Epoch 272/800
24/24 [==============================] - 0s 323us/step - loss: 0.0241
Epoch 273/800
24/24 [==============================] - 0s 305us/step - loss: 0.0245
```

```
Epoch 274/800
24/24 [==============================] - 0s 328us/step - loss: 0.0241
Epoch 275/800
24/24 [==============================] - 0s 494us/step - loss: 0.0242
Epoch 276/800
24/24 [==============================] - 0s 541us/step - loss: 0.0242
Epoch 277/800
24/24 [==============================] - 0s 248us/step - loss: 0.0250
Epoch 278/800
24/24 [==============================] - 0s 306us/step - loss: 0.0245
Epoch 279/800
24/24 [==============================] - 0s 342us/step - loss: 0.0253
Epoch 280/800
24/24 [==============================] - 0s 393us/step - loss: 0.0250
Epoch 281/800
24/24 [==============================] - 0s 352us/step - loss: 0.0245
Epoch 282/800
24/24 [==============================] - 0s 400us/step - loss: 0.0255
Epoch 283/800
24/24 [==============================] - 0s 318us/step - loss: 0.0253
Epoch 284/800
24/24 [==============================] - 0s 372us/step - loss: 0.0239
Epoch 285/800
24/24 [==============================] - 0s 489us/step - loss: 0.0238
Epoch 286/800
24/24 [==============================] - 0s 203us/step - loss: 0.0235
Epoch 287/800
24/24 [==============================] - 0s 302us/step - loss: 0.0237
Epoch 288/800
24/24 [==============================] - 0s 254us/step - loss: 0.0238
Epoch 289/800
24/24 [==============================] - 0s 252us/step - loss: 0.0235
Epoch 290/800
24/24 [==============================] - 0s 176us/step - loss: 0.0239
Epoch 291/800
24/24 [==============================] - 0s 192us/step - loss: 0.0240
Epoch 292/800
24/24 [==============================] - 0s 209us/step - loss: 0.0243
Epoch 293/800
24/24 [==============================] - 0s 308us/step - loss: 0.0254
Epoch 294/800
24/24 [==============================] - 0s 265us/step - loss: 0.0238
Epoch 295/800
24/24 [==============================] - 0s 230us/step - loss: 0.0245
Epoch 296/800
24/24 [==============================] - 0s 276us/step - loss: 0.0240
Epoch 297/800
24/24 [==============================] - 0s 229us/step - loss: 0.0236
Epoch 298/800
24/24 [==============================] - 0s 366us/step - loss: 0.0235
Epoch 299/800
24/24 [==============================] - 0s 329us/step - loss: 0.0238
Epoch 300/800
24/24 [==============================] - 0s 300us/step - loss: 0.0237
Epoch 301/800
24/24 [==============================] - 0s 204us/step - loss: 0.0241
Epoch 302/800
```

```
24/24 [==============================] - 0s 411us/step - loss: 0.0238
Epoch 303/800
24/24 [==============================] - 0s 532us/step - loss: 0.0237
Epoch 304/800
24/24 [==============================] - 0s 772us/step - loss: 0.0234
Epoch 305/800
24/24 [==============================] - 0s 856us/step - loss: 0.0230
Epoch 306/800
24/24 [==============================] - 0s 383us/step - loss: 0.0228
Epoch 307/800
24/24 [==============================] - 0s 276us/step - loss: 0.0231
Epoch 308/800
24/24 [==============================] - 0s 320us/step - loss: 0.0245
Epoch 309/800
24/24 [==============================] - 0s 407us/step - loss: 0.0248
Epoch 310/800
24/24 [==============================] - 0s 350us/step - loss: 0.0238
Epoch 311/800
24/24 [==============================] - 0s 321us/step - loss: 0.0246
Epoch 312/800
24/24 [==============================] - 0s 804us/step - loss: 0.0234
Epoch 313/800
24/24 [==============================] - 0s 332us/step - loss: 0.0233
Epoch 314/800
24/24 [==============================] - 0s 244us/step - loss: 0.0226
Epoch 315/800
24/24 [==============================] - 0s 175us/step - loss: 0.0229
Epoch 316/800
24/24 [==============================] - 0s 201us/step - loss: 0.0237
Epoch 317/800
24/24 [==============================] - 0s 204us/step - loss: 0.0236
Epoch 318/800
24/24 [==============================] - 0s 213us/step - loss: 0.0230
Epoch 319/800
24/24 [==============================] - 0s 213us/step - loss: 0.0227
Epoch 320/800
24/24 [==============================] - 0s 199us/step - loss: 0.0224
Epoch 321/800
24/24 [==============================] - 0s 276us/step - loss: 0.0225
Epoch 322/800
24/24 [==============================] - 0s 300us/step - loss: 0.0231
Epoch 323/800
24/24 [==============================] - 0s 313us/step - loss: 0.0234
Epoch 324/800
24/24 [==============================] - 0s 299us/step - loss: 0.0232
Epoch 325/800
24/24 [==============================] - 0s 288us/step - loss: 0.0235
Epoch 326/800
24/24 [==============================] - 0s 427us/step - loss: 0.0230
Epoch 327/800
24/24 [==============================] - 0s 246us/step - loss: 0.0229
Epoch 328/800
24/24 [==============================] - 0s 243us/step - loss: 0.0223
Epoch 329/800
24/24 [==============================] - 0s 293us/step - loss: 0.0221
Epoch 330/800
24/24 [==============================] - 0s 257us/step - loss: 0.0220
```

```
Epoch 331/800
24/24 [==============================] - 0s 387us/step - loss: 0.0234
Epoch 332/800
24/24 [==============================] - 0s 232us/step - loss: 0.0226
Epoch 333/800
24/24 [==============================] - 0s 227us/step - loss: 0.0226
Epoch 334/800
24/24 [==============================] - 0s 331us/step - loss: 0.0229
Epoch 335/800
24/24 [==============================] - 0s 266us/step - loss: 0.0238
Epoch 336/800
24/24 [==============================] - 0s 410us/step - loss: 0.0227
Epoch 337/800
24/24 [==============================] - 0s 208us/step - loss: 0.0230
Epoch 338/800
24/24 [==============================] - 0s 305us/step - loss: 0.0220
Epoch 339/800
24/24 [==============================] - 0s 336us/step - loss: 0.0225
Epoch 340/800
24/24 [==============================] - 0s 310us/step - loss: 0.0229
Epoch 341/800
24/24 [==============================] - 0s 294us/step - loss: 0.0234
Epoch 342/800
24/24 [==============================] - 0s 271us/step - loss: 0.0220
Epoch 343/800
24/24 [==============================] - 0s 210us/step - loss: 0.0215
Epoch 344/800
24/24 [==============================] - 0s 174us/step - loss: 0.0214
Epoch 345/800
24/24 [==============================] - 0s 276us/step - loss: 0.0212
Epoch 346/800
24/24 [==============================] - 0s 335us/step - loss: 0.0214
Epoch 347/800
24/24 [==============================] - 0s 333us/step - loss: 0.0219
Epoch 348/800
24/24 [==============================] - 0s 257us/step - loss: 0.0236
Epoch 349/800
24/24 [==============================] - 0s 281us/step - loss: 0.0255
Epoch 350/800
24/24 [==============================] - 0s 429us/step - loss: 0.0235
Epoch 351/800
24/24 [==============================] - 0s 334us/step - loss: 0.0230
Epoch 352/800
24/24 [==============================] - 0s 286us/step - loss: 0.0216
Epoch 353/800
24/24 [==============================] - 0s 234us/step - loss: 0.0213
Epoch 354/800
24/24 [==============================] - 0s 358us/step - loss: 0.0213
Epoch 355/800
24/24 [==============================] - 0s 292us/step - loss: 0.0216
Epoch 356/800
24/24 [==============================] - 0s 406us/step - loss: 0.0218
Epoch 357/800
24/24 [==============================] - 0s 351us/step - loss: 0.0214
Epoch 358/800
24/24 [==============================] - 0s 373us/step - loss: 0.0210
Epoch 359/800
```

```
24/24 [==============================] - 0s 504us/step - loss: 0.0211
Epoch 360/800
24/24 [==============================] - 0s 540us/step - loss: 0.0219
Epoch 361/800
24/24 [==============================] - 0s 815us/step - loss: 0.0226
Epoch 362/800
24/24 [==============================] - 0s 207us/step - loss: 0.0214
Epoch 363/800
24/24 [==============================] - 0s 302us/step - loss: 0.0213
Epoch 364/800
24/24 [==============================] - 0s 243us/step - loss: 0.0207
Epoch 365/800
24/24 [==============================] - 0s 187us/step - loss: 0.0209
Epoch 366/800
24/24 [==============================] - 0s 260us/step - loss: 0.0212
Epoch 367/800
24/24 [==============================] - 0s 209us/step - loss: 0.0224
Epoch 368/800
24/24 [==============================] - 0s 354us/step - loss: 0.0207
Epoch 369/800
24/24 [==============================] - 0s 245us/step - loss: 0.0207
Epoch 370/800
24/24 [==============================] - 0s 339us/step - loss: 0.0226
Epoch 371/800
24/24 [==============================] - 0s 231us/step - loss: 0.0225
Epoch 372/800
24/24 [==============================] - 0s 294us/step - loss: 0.0249
Epoch 373/800
24/24 [==============================] - 0s 627us/step - loss: 0.0226
Epoch 374/800
24/24 [==============================] - 0s 216us/step - loss: 0.0217
Epoch 375/800
24/24 [==============================] - 0s 269us/step - loss: 0.0208
Epoch 376/800
24/24 [==============================] - 0s 286us/step - loss: 0.0205
Epoch 377/800
24/24 [==============================] - 0s 504us/step - loss: 0.0204
Epoch 378/800
24/24 [==============================] - 0s 326us/step - loss: 0.0205
Epoch 379/800
24/24 [==============================] - 0s 354us/step - loss: 0.0212
Epoch 380/800
24/24 [==============================] - 0s 290us/step - loss: 0.0203
Epoch 381/800
24/24 [==============================] - 0s 258us/step - loss: 0.0207
Epoch 382/800
24/24 [==============================] - 0s 318us/step - loss: 0.0204
Epoch 383/800
24/24 [==============================] - 0s 335us/step - loss: 0.0206
Epoch 384/800
24/24 [==============================] - 0s 274us/step - loss: 0.0203
Epoch 385/800
24/24 [==============================] - 0s 315us/step - loss: 0.0217
Epoch 386/800
24/24 [==============================] - 0s 312us/step - loss: 0.0222
Epoch 387/800
24/24 [==============================] - 0s 305us/step - loss: 0.0218
```

```
Epoch 388/800
24/24 [==============================] - 0s 311us/step - loss: 0.0209
Epoch 389/800
24/24 [==============================] - 0s 195us/step - loss: 0.0214
Epoch 390/800
24/24 [==============================] - 0s 213us/step - loss: 0.0208
Epoch 391/800
24/24 [==============================] - 0s 211us/step - loss: 0.0200
Epoch 392/800
24/24 [==============================] - 0s 362us/step - loss: 0.0200
Epoch 393/800
24/24 [==============================] - 0s 218us/step - loss: 0.0208
Epoch 394/800
24/24 [==============================] - 0s 184us/step - loss: 0.0216
Epoch 395/800
24/24 [==============================] - 0s 309us/step - loss: 0.0214
Epoch 396/800
24/24 [==============================] - 0s 291us/step - loss: 0.0217
Epoch 397/800
24/24 [==============================] - 0s 428us/step - loss: 0.0212
Epoch 398/800
24/24 [==============================] - 0s 214us/step - loss: 0.0203
Epoch 399/800
24/24 [==============================] - 0s 227us/step - loss: 0.0201
Epoch 400/800
24/24 [==============================] - 0s 314us/step - loss: 0.0198
Epoch 401/800
24/24 [==============================] - 0s 199us/step - loss: 0.0200
Epoch 402/800
24/24 [==============================] - 0s 273us/step - loss: 0.0205
Epoch 403/800
24/24 [==============================] - 0s 318us/step - loss: 0.0196
Epoch 404/800
24/24 [==============================] - 0s 279us/step - loss: 0.0205
Epoch 405/800
24/24 [==============================] - 0s 343us/step - loss: 0.0196
Epoch 406/800
24/24 [==============================] - 0s 215us/step - loss: 0.0199
Epoch 407/800
24/24 [==============================] - 0s 343us/step - loss: 0.0204
Epoch 408/800
24/24 [==============================] - 0s 301us/step - loss: 0.0193
Epoch 409/800
24/24 [==============================] - 0s 517us/step - loss: 0.0198
Epoch 410/800
24/24 [==============================] - 0s 338us/step - loss: 0.0198
Epoch 411/800
24/24 [==============================] - 0s 469us/step - loss: 0.0216
Epoch 412/800
24/24 [==============================] - 0s 339us/step - loss: 0.0222
Epoch 413/800
24/24 [==============================] - 0s 499us/step - loss: 0.0234
Epoch 414/800
24/24 [==============================] - 0s 549us/step - loss: 0.0220
Epoch 415/800
24/24 [==============================] - 0s 483us/step - loss: 0.0197
Epoch 416/800
```

```
24/24 [==============================] - 0s 203us/step - loss: 0.0195
Epoch 417/800
24/24 [==============================] - 0s 297us/step - loss: 0.0193
Epoch 418/800
24/24 [==============================] - 0s 320us/step - loss: 0.0192
Epoch 419/800
24/24 [==============================] - 0s 293us/step - loss: 0.0203
Epoch 420/800
24/24 [==============================] - 0s 491us/step - loss: 0.0198
Epoch 421/800
24/24 [==============================] - 0s 719us/step - loss: 0.0195
Epoch 422/800
24/24 [==============================] - 0s 651us/step - loss: 0.0199
Epoch 423/800
24/24 [==============================] - 0s 508us/step - loss: 0.0200
Epoch 424/800
24/24 [==============================] - 0s 1ms/step - loss: 0.0197
Epoch 425/800
24/24 [==============================] - 0s 678us/step - loss: 0.0203
Epoch 426/800
24/24 [==============================] - 0s 619us/step - loss: 0.0189
Epoch 427/800
24/24 [==============================] - 0s 384us/step - loss: 0.0189
Epoch 428/800
24/24 [==============================] - 0s 523us/step - loss: 0.0189
Epoch 429/800
24/24 [==============================] - 0s 309us/step - loss: 0.0194
Epoch 430/800
24/24 [==============================] - 0s 265us/step - loss: 0.0190
Epoch 431/800
24/24 [==============================] - 0s 328us/step - loss: 0.0194
Epoch 432/800
24/24 [==============================] - 0s 290us/step - loss: 0.0187
Epoch 433/800
24/24 [==============================] - 0s 299us/step - loss: 0.0200
Epoch 434/800
24/24 [==============================] - 0s 255us/step - loss: 0.0210
Epoch 435/800
24/24 [==============================] - 0s 538us/step - loss: 0.0219
Epoch 436/800
24/24 [==============================] - 0s 245us/step - loss: 0.0218
Epoch 437/800
24/24 [==============================] - 0s 402us/step - loss: 0.0205
Epoch 438/800
24/24 [==============================] - 0s 719us/step - loss: 0.0194
Epoch 439/800
24/24 [==============================] - 0s 235us/step - loss: 0.0186
Epoch 440/800
24/24 [==============================] - 0s 171us/step - loss: 0.0186
Epoch 441/800
24/24 [==============================] - 0s 205us/step - loss: 0.0184
Epoch 442/800
24/24 [==============================] - 0s 245us/step - loss: 0.0190
Epoch 443/800
24/24 [==============================] - 0s 263us/step - loss: 0.0189
Epoch 444/800
24/24 [==============================] - 0s 357us/step - loss: 0.0192
```

```
Epoch 445/800
24/24 [==============================] - 0s 276us/step - loss: 0.0194
Epoch 446/800
24/24 [==============================] - 0s 291us/step - loss: 0.0186
Epoch 447/800
24/24 [==============================] - 0s 292us/step - loss: 0.0190
Epoch 448/800
24/24 [==============================] - 0s 316us/step - loss: 0.0187
Epoch 449/800
24/24 [==============================] - 0s 308us/step - loss: 0.0204
Epoch 450/800
24/24 [==============================] - 0s 259us/step - loss: 0.0224
Epoch 451/800
24/24 [==============================] - 0s 296us/step - loss: 0.0211
Epoch 452/800
24/24 [==============================] - 0s 242us/step - loss: 0.0208
Epoch 453/800
24/24 [==============================] - 0s 255us/step - loss: 0.0186
Epoch 454/800
24/24 [==============================] - 0s 213us/step - loss: 0.0186
Epoch 455/800
24/24 [==============================] - 0s 273us/step - loss: 0.0181
Epoch 456/800
24/24 [==============================] - 0s 466us/step - loss: 0.0179
Epoch 457/800
24/24 [==============================] - 0s 608us/step - loss: 0.0179
Epoch 458/800
24/24 [==============================] - 0s 225us/step - loss: 0.0182
Epoch 459/800
24/24 [==============================] - 0s 648us/step - loss: 0.0180
Epoch 460/800
24/24 [==============================] - 0s 588us/step - loss: 0.0178
Epoch 461/800
24/24 [==============================] - 0s 218us/step - loss: 0.0178
Epoch 462/800
24/24 [==============================] - 0s 274us/step - loss: 0.0181
Epoch 463/800
24/24 [==============================] - 0s 314us/step - loss: 0.0179
Epoch 464/800
24/24 [==============================] - 0s 367us/step - loss: 0.0180
Epoch 465/800
24/24 [==============================] - 0s 346us/step - loss: 0.0189
Epoch 466/800
24/24 [==============================] - 0s 343us/step - loss: 0.0183
Epoch 467/800
24/24 [==============================] - 0s 365us/step - loss: 0.0216
Epoch 468/800
24/24 [==============================] - 0s 332us/step - loss: 0.0229
Epoch 469/800
24/24 [==============================] - 0s 351us/step - loss: 0.0203
Epoch 470/800
24/24 [==============================] - 0s 238us/step - loss: 0.0191
Epoch 471/800
24/24 [==============================] - 0s 250us/step - loss: 0.0193
Epoch 472/800
24/24 [==============================] - 0s 255us/step - loss: 0.0190
Epoch 473/800
```

```
24/24 [==============================] - 0s 260us/step - loss: 0.0177
Epoch 474/800
24/24 [==============================] - 0s 283us/step - loss: 0.0178
Epoch 475/800
24/24 [==============================] - 0s 231us/step - loss: 0.0181
Epoch 476/800
24/24 [==============================] - 0s 299us/step - loss: 0.0178
Epoch 477/800
24/24 [==============================] - 0s 299us/step - loss: 0.0174
Epoch 478/800
24/24 [==============================] - 0s 257us/step - loss: 0.0176
Epoch 479/800
24/24 [==============================] - 0s 296us/step - loss: 0.0185
Epoch 480/800
24/24 [==============================] - 0s 262us/step - loss: 0.0187
Epoch 481/800
24/24 [==============================] - 0s 487us/step - loss: 0.0203
Epoch 482/800
24/24 [==============================] - 0s 310us/step - loss: 0.0191
Epoch 483/800
24/24 [==============================] - 0s 248us/step - loss: 0.0181
Epoch 484/800
24/24 [==============================] - 0s 301us/step - loss: 0.0185
Epoch 485/800
24/24 [==============================] - 0s 514us/step - loss: 0.0189
Epoch 486/800
24/24 [==============================] - 0s 264us/step - loss: 0.0184
Epoch 487/800
24/24 [==============================] - 0s 394us/step - loss: 0.0173
Epoch 488/800
24/24 [==============================] - 0s 366us/step - loss: 0.0176
Epoch 489/800
24/24 [==============================] - 0s 249us/step - loss: 0.0173
Epoch 490/800
24/24 [==============================] - 0s 196us/step - loss: 0.0173
Epoch 491/800
24/24 [==============================] - 0s 288us/step - loss: 0.0171
Epoch 492/800
24/24 [==============================] - 0s 298us/step - loss: 0.0173
Epoch 493/800
24/24 [==============================] - 0s 225us/step - loss: 0.0177
Epoch 494/800
24/24 [==============================] - 0s 216us/step - loss: 0.0196
Epoch 495/800
24/24 [==============================] - 0s 179us/step - loss: 0.0200
Epoch 496/800
24/24 [==============================] - 0s 271us/step - loss: 0.0207
Epoch 497/800
24/24 [==============================] - 0s 233us/step - loss: 0.0195
Epoch 498/800
24/24 [==============================] - 0s 284us/step - loss: 0.0194
Epoch 499/800
24/24 [==============================] - 0s 396us/step - loss: 0.0184
Epoch 500/800
24/24 [==============================] - 0s 243us/step - loss: 0.0170
Epoch 501/800
24/24 [==============================] - 0s 465us/step - loss: 0.0169
```

```
Epoch 502/800
24/24 [==============================] - 0s 423us/step - loss: 0.0170
Epoch 503/800
24/24 [==============================] - 0s 339us/step - loss: 0.0181
Epoch 504/800
24/24 [==============================] - 0s 317us/step - loss: 0.0185
Epoch 505/800
24/24 [==============================] - 0s 591us/step - loss: 0.0181
Epoch 506/800
24/24 [==============================] - 0s 877us/step - loss: 0.0175
Epoch 507/800
24/24 [==============================] - 0s 906us/step - loss: 0.0178
Epoch 508/800
24/24 [==============================] - 0s 841us/step - loss: 0.0178
Epoch 509/800
24/24 [==============================] - 0s 477us/step - loss: 0.0181
Epoch 510/800
24/24 [==============================] - 0s 312us/step - loss: 0.0192
Epoch 511/800
24/24 [==============================] - 0s 309us/step - loss: 0.0183
Epoch 512/800
24/24 [==============================] - 0s 258us/step - loss: 0.0177
Epoch 513/800
24/24 [==============================] - 0s 442us/step - loss: 0.0166
Epoch 514/800
24/24 [==============================] - 0s 611us/step - loss: 0.0165
Epoch 515/800
24/24 [==============================] - 0s 361us/step - loss: 0.0169
Epoch 516/800
24/24 [==============================] - 0s 261us/step - loss: 0.0179
Epoch 517/800
24/24 [==============================] - 0s 287us/step - loss: 0.0168
Epoch 518/800
24/24 [==============================] - 0s 227us/step - loss: 0.0177
Epoch 519/800
24/24 [==============================] - 0s 279us/step - loss: 0.0193
Epoch 520/800
24/24 [==============================] - 0s 331us/step - loss: 0.0200
Epoch 521/800
24/24 [==============================] - 0s 217us/step - loss: 0.0201
Epoch 522/800
24/24 [==============================] - 0s 301us/step - loss: 0.0181
Epoch 523/800
24/24 [==============================] - 0s 309us/step - loss: 0.0173
Epoch 524/800
24/24 [==============================] - 0s 349us/step - loss: 0.0164
Epoch 525/800
24/24 [==============================] - 0s 309us/step - loss: 0.0165
Epoch 526/800
24/24 [==============================] - 0s 194us/step - loss: 0.0165
Epoch 527/800
24/24 [==============================] - 0s 295us/step - loss: 0.0173
Epoch 528/800
24/24 [==============================] - 0s 183us/step - loss: 0.0171
Epoch 529/800
24/24 [==============================] - 0s 279us/step - loss: 0.0174
Epoch 530/800
```

```
24/24 [==============================] - 0s 479us/step - loss: 0.0162
Epoch 531/800
24/24 [==============================] - 0s 205us/step - loss: 0.0161
Epoch 532/800
24/24 [==============================] - 0s 247us/step - loss: 0.0172
Epoch 533/800
24/24 [==============================] - 0s 268us/step - loss: 0.0197
Epoch 534/800
24/24 [==============================] - 0s 220us/step - loss: 0.0183
Epoch 535/800
24/24 [==============================] - 0s 375us/step - loss: 0.0198
Epoch 536/800
24/24 [==============================] - 0s 494us/step - loss: 0.0196
Epoch 537/800
24/24 [==============================] - 0s 314us/step - loss: 0.0179
Epoch 538/800
24/24 [==============================] - 0s 874us/step - loss: 0.0170
Epoch 539/800
24/24 [==============================] - 0s 435us/step - loss: 0.0163
Epoch 540/800
24/24 [==============================] - 0s 556us/step - loss: 0.0165
Epoch 541/800
24/24 [==============================] - 0s 1ms/step - loss: 0.0175
Epoch 542/800
24/24 [==============================] - 0s 656us/step - loss: 0.0178
Epoch 543/800
24/24 [==============================] - 0s 748us/step - loss: 0.0186
Epoch 544/800
24/24 [==============================] - 0s 424us/step - loss: 0.0183
Epoch 545/800
24/24 [==============================] - 0s 386us/step - loss: 0.0177
Epoch 546/800
24/24 [==============================] - 0s 446us/step - loss: 0.0171
Epoch 547/800
24/24 [==============================] - 0s 451us/step - loss: 0.0159
Epoch 548/800
24/24 [==============================] - 0s 496us/step - loss: 0.0156
Epoch 549/800
24/24 [==============================] - 0s 222us/step - loss: 0.0162
Epoch 550/800
24/24 [==============================] - 0s 244us/step - loss: 0.0165
Epoch 551/800
24/24 [==============================] - 0s 275us/step - loss: 0.0170
Epoch 552/800
24/24 [==============================] - 0s 236us/step - loss: 0.0163
Epoch 553/800
24/24 [==============================] - 0s 322us/step - loss: 0.0156
Epoch 554/800
24/24 [==============================] - 0s 251us/step - loss: 0.0166
Epoch 555/800
24/24 [==============================] - 0s 273us/step - loss: 0.0173
Epoch 556/800
24/24 [==============================] - 0s 251us/step - loss: 0.0180
Epoch 557/800
24/24 [==============================] - 0s 297us/step - loss: 0.0200
Epoch 558/800
24/24 [==============================] - 0s 323us/step - loss: 0.0190
```

```
Epoch 559/800
24/24 [==============================] - 0s 286us/step - loss: 0.0178
Epoch 560/800
24/24 [==============================] - 0s 590us/step - loss: 0.0169
Epoch 561/800
24/24 [==============================] - 0s 391us/step - loss: 0.0159
Epoch 562/800
24/24 [==============================] - 0s 245us/step - loss: 0.0168
Epoch 563/800
24/24 [==============================] - 0s 232us/step - loss: 0.0174
Epoch 564/800
24/24 [==============================] - 0s 289us/step - loss: 0.0172
Epoch 565/800
24/24 [==============================] - 0s 209us/step - loss: 0.0158
Epoch 566/800
24/24 [==============================] - 0s 198us/step - loss: 0.0165
Epoch 567/800
24/24 [==============================] - 0s 247us/step - loss: 0.0175
Epoch 568/800
24/24 [==============================] - 0s 254us/step - loss: 0.0167
Epoch 569/800
24/24 [==============================] - 0s 341us/step - loss: 0.0179
Epoch 570/800
24/24 [==============================] - 0s 273us/step - loss: 0.0183
Epoch 571/800
24/24 [==============================] - 0s 239us/step - loss: 0.0168
Epoch 572/800
24/24 [==============================] - 0s 375us/step - loss: 0.0156
Epoch 573/800
24/24 [==============================] - 0s 279us/step - loss: 0.0155
Epoch 574/800
24/24 [==============================] - 0s 239us/step - loss: 0.0168
Epoch 575/800
24/24 [==============================] - 0s 308us/step - loss: 0.0170
Epoch 576/800
24/24 [==============================] - 0s 293us/step - loss: 0.0169
Epoch 577/800
24/24 [==============================] - 0s 306us/step - loss: 0.0168
Epoch 578/800
24/24 [==============================] - 0s 330us/step - loss: 0.0161
Epoch 579/800
24/24 [==============================] - 0s 362us/step - loss: 0.0179
Epoch 580/800
24/24 [==============================] - 0s 333us/step - loss: 0.0174
Epoch 581/800
24/24 [==============================] - 0s 308us/step - loss: 0.0171
Epoch 582/800
24/24 [==============================] - 0s 211us/step - loss: 0.0180
Epoch 583/800
24/24 [==============================] - 0s 298us/step - loss: 0.0164
Epoch 584/800
24/24 [==============================] - 0s 505us/step - loss: 0.0163
Epoch 585/800
24/24 [==============================] - 0s 255us/step - loss: 0.0154
Epoch 586/800
24/24 [==============================] - 0s 303us/step - loss: 0.0173
Epoch 587/800
```

```
24/24 [==============================] - 0s 225us/step - loss: 0.0151
Epoch 588/800
24/24 [==============================] - 0s 300us/step - loss: 0.0151
Epoch 589/800
24/24 [==============================] - 0s 454us/step - loss: 0.0170
Epoch 590/800
24/24 [==============================] - 0s 397us/step - loss: 0.0169
Epoch 591/800
24/24 [==============================] - 0s 461us/step - loss: 0.0169
Epoch 592/800
24/24 [==============================] - 0s 235us/step - loss: 0.0173
Epoch 593/800
24/24 [==============================] - 0s 251us/step - loss: 0.0169
Epoch 594/800
24/24 [==============================] - 0s 301us/step - loss: 0.0177
Epoch 595/800
24/24 [==============================] - 0s 357us/step - loss: 0.0166
Epoch 596/800
24/24 [==============================] - 0s 270us/step - loss: 0.0159
Epoch 597/800
24/24 [==============================] - 0s 344us/step - loss: 0.0161
Epoch 598/800
24/24 [==============================] - 0s 228us/step - loss: 0.0162
Epoch 599/800
24/24 [==============================] - 0s 397us/step - loss: 0.0151
Epoch 600/800
24/24 [==============================] - 0s 319us/step - loss: 0.0163
Epoch 601/800
24/24 [==============================] - 0s 1ms/step - loss: 0.0167
Epoch 602/800
24/24 [==============================] - 0s 286us/step - loss: 0.0164
Epoch 603/800
24/24 [==============================] - 0s 261us/step - loss: 0.0171
Epoch 604/800
24/24 [==============================] - 0s 313us/step - loss: 0.0190
Epoch 605/800
24/24 [==============================] - 0s 267us/step - loss: 0.0159
Epoch 606/800
24/24 [==============================] - 0s 277us/step - loss: 0.0149
Epoch 607/800
24/24 [==============================] - 0s 203us/step - loss: 0.0149
Epoch 608/800
24/24 [==============================] - 0s 343us/step - loss: 0.0173
Epoch 609/800
24/24 [==============================] - 0s 327us/step - loss: 0.0149
Epoch 610/800
24/24 [==============================] - 0s 265us/step - loss: 0.0148
Epoch 611/800
24/24 [==============================] - 0s 323us/step - loss: 0.0148
Epoch 612/800
24/24 [==============================] - 0s 248us/step - loss: 0.0167
Epoch 613/800
24/24 [==============================] - 0s 385us/step - loss: 0.0170
Epoch 614/800
24/24 [==============================] - 0s 301us/step - loss: 0.0172
Epoch 615/800
24/24 [==============================] - 0s 255us/step - loss: 0.0170
```

```
Epoch 616/800
24/24 [==============================] - 0s 299us/step - loss: 0.0177
Epoch 617/800
24/24 [==============================] - 0s 408us/step - loss: 0.0184
Epoch 618/800
24/24 [==============================] - 0s 314us/step - loss: 0.0162
Epoch 619/800
24/24 [==============================] - 0s 309us/step - loss: 0.0162
Epoch 620/800
24/24 [==============================] - 0s 291us/step - loss: 0.0161
Epoch 621/800
24/24 [==============================] - 0s 348us/step - loss: 0.0153
Epoch 622/800
24/24 [==============================] - 0s 429us/step - loss: 0.0165
Epoch 623/800
24/24 [==============================] - 0s 578us/step - loss: 0.0173
Epoch 624/800
24/24 [==============================] - 0s 237us/step - loss: 0.0157
Epoch 625/800
24/24 [==============================] - 0s 328us/step - loss: 0.0147
Epoch 626/800
24/24 [==============================] - 0s 219us/step - loss: 0.0146
Epoch 627/800
24/24 [==============================] - 0s 220us/step - loss: 0.0173
Epoch 628/800
24/24 [==============================] - 0s 312us/step - loss: 0.0149
Epoch 629/800
24/24 [==============================] - 0s 265us/step - loss: 0.0169
Epoch 630/800
24/24 [==============================] - 0s 276us/step - loss: 0.0169
Epoch 631/800
24/24 [==============================] - 0s 226us/step - loss: 0.0163
Epoch 632/800
24/24 [==============================] - 0s 240us/step - loss: 0.0184
Epoch 633/800
24/24 [==============================] - 0s 202us/step - loss: 0.0158
Epoch 634/800
24/24 [==============================] - 0s 222us/step - loss: 0.0159
Epoch 635/800
24/24 [==============================] - 0s 792us/step - loss: 0.0141
Epoch 636/800
24/24 [==============================] - 0s 291us/step - loss: 0.0142
Epoch 637/800
24/24 [==============================] - 0s 295us/step - loss: 0.0153
Epoch 638/800
24/24 [==============================] - 0s 328us/step - loss: 0.0156
Epoch 639/800
24/24 [==============================] - 0s 401us/step - loss: 0.0169
Epoch 640/800
24/24 [==============================] - 0s 254us/step - loss: 0.0174
Epoch 641/800
24/24 [==============================] - 0s 282us/step - loss: 0.0161
Epoch 642/800
24/24 [==============================] - 0s 280us/step - loss: 0.0163
Epoch 643/800
24/24 [==============================] - 0s 270us/step - loss: 0.0162
Epoch 644/800
```

```
24/24 [==============================] - 0s 289us/step - loss: 0.0155
Epoch 645/800
24/24 [==============================] - 0s 233us/step - loss: 0.0160
Epoch 646/800
24/24 [==============================] - 0s 220us/step - loss: 0.0160
Epoch 647/800
24/24 [==============================] - 0s 227us/step - loss: 0.0159
Epoch 648/800
24/24 [==============================] - 0s 215us/step - loss: 0.0155
Epoch 649/800
24/24 [==============================] - 0s 303us/step - loss: 0.0142
Epoch 650/800
24/24 [==============================] - 0s 323us/step - loss: 0.0156
Epoch 651/800
24/24 [==============================] - 0s 544us/step - loss: 0.0170
Epoch 652/800
24/24 [==============================] - 0s 393us/step - loss: 0.0167
Epoch 653/800
24/24 [==============================] - 0s 292us/step - loss: 0.0155
Epoch 654/800
24/24 [==============================] - 0s 226us/step - loss: 0.0163
Epoch 655/800
24/24 [==============================] - 0s 244us/step - loss: 0.0158
Epoch 656/800
24/24 [==============================] - 0s 480us/step - loss: 0.0165
Epoch 657/800
24/24 [==============================] - 0s 401us/step - loss: 0.0160
Epoch 658/800
24/24 [==============================] - 0s 828us/step - loss: 0.0155
Epoch 659/800
24/24 [==============================] - 0s 671us/step - loss: 0.0150
Epoch 660/800
24/24 [==============================] - 0s 897us/step - loss: 0.0141
Epoch 661/800
24/24 [==============================] - 0s 223us/step - loss: 0.0142
Epoch 662/800
24/24 [==============================] - 0s 304us/step - loss: 0.0155
Epoch 663/800
24/24 [==============================] - 0s 326us/step - loss: 0.0158
Epoch 664/800
24/24 [==============================] - 0s 323us/step - loss: 0.0172
Epoch 665/800
24/24 [==============================] - 0s 251us/step - loss: 0.0152
Epoch 666/800
24/24 [==============================] - 0s 297us/step - loss: 0.0153
Epoch 667/800
24/24 [==============================] - 0s 354us/step - loss: 0.0162
Epoch 668/800
24/24 [==============================] - 0s 266us/step - loss: 0.0178
Epoch 669/800
24/24 [==============================] - 0s 301us/step - loss: 0.0157
Epoch 670/800
24/24 [==============================] - 0s 255us/step - loss: 0.0149
Epoch 671/800
24/24 [==============================] - 0s 306us/step - loss: 0.0140
Epoch 672/800
24/24 [==============================] - 0s 268us/step - loss: 0.0151
```

```
Epoch 673/800
24/24 [==============================] - 0s 336us/step - loss: 0.0139
Epoch 674/800
24/24 [==============================] - 0s 387us/step - loss: 0.0156
Epoch 675/800
24/24 [==============================] - 0s 225us/step - loss: 0.0155
Epoch 676/800
24/24 [==============================] - 0s 213us/step - loss: 0.0155
Epoch 677/800
24/24 [==============================] - 0s 335us/step - loss: 0.0150
Epoch 678/800
24/24 [==============================] - 0s 245us/step - loss: 0.0161
Epoch 679/800
24/24 [==============================] - 0s 267us/step - loss: 0.0187
Epoch 680/800
24/24 [==============================] - 0s 324us/step - loss: 0.0153
Epoch 681/800
24/24 [==============================] - 0s 349us/step - loss: 0.0146
Epoch 682/800
24/24 [==============================] - 0s 285us/step - loss: 0.0139
Epoch 683/800
24/24 [==============================] - 0s 279us/step - loss: 0.0164
Epoch 684/800
24/24 [==============================] - 0s 294us/step - loss: 0.0165
Epoch 685/800
24/24 [==============================] - 0s 285us/step - loss: 0.0166
Epoch 686/800
24/24 [==============================] - 0s 355us/step - loss: 0.0156
Epoch 687/800
24/24 [==============================] - 0s 246us/step - loss: 0.0161
Epoch 688/800
24/24 [==============================] - 0s 503us/step - loss: 0.0154
Epoch 689/800
24/24 [==============================] - 0s 245us/step - loss: 0.0150
Epoch 690/800
24/24 [==============================] - 0s 296us/step - loss: 0.0162
Epoch 691/800
24/24 [==============================] - 0s 265us/step - loss: 0.0167
Epoch 692/800
24/24 [==============================] - 0s 324us/step - loss: 0.0149
Epoch 693/800
24/24 [==============================] - 0s 311us/step - loss: 0.0152
Epoch 694/800
24/24 [==============================] - 0s 258us/step - loss: 0.0150
Epoch 695/800
24/24 [==============================] - 0s 291us/step - loss: 0.0157
Epoch 696/800
24/24 [==============================] - 0s 286us/step - loss: 0.0156
Epoch 697/800
24/24 [==============================] - 0s 193us/step - loss: 0.0162
Epoch 698/800
24/24 [==============================] - 0s 279us/step - loss: 0.0151
Epoch 699/800
24/24 [==============================] - 0s 328us/step - loss: 0.0152
Epoch 700/800
24/24 [==============================] - 0s 583us/step - loss: 0.0142
Epoch 701/800
```

```
24/24 [==============================] - 0s 563us/step - loss: 0.0144
Epoch 702/800
24/24 [==============================] - 0s 389us/step - loss: 0.0150
Epoch 703/800
24/24 [==============================] - 0s 417us/step - loss: 0.0157
Epoch 704/800
24/24 [==============================] - 0s 527us/step - loss: 0.0152
Epoch 705/800
24/24 [==============================] - 0s 532us/step - loss: 0.0161
Epoch 706/800
24/24 [==============================] - 0s 754us/step - loss: 0.0156
Epoch 707/800
24/24 [==============================] - 0s 224us/step - loss: 0.0156
Epoch 708/800
24/24 [==============================] - 0s 279us/step - loss: 0.0153
Epoch 709/800
24/24 [==============================] - 0s 259us/step - loss: 0.0162
Epoch 710/800
24/24 [==============================] - 0s 305us/step - loss: 0.0151
Epoch 711/800
24/24 [==============================] - 0s 331us/step - loss: 0.0154
Epoch 712/800
24/24 [==============================] - 0s 256us/step - loss: 0.0151
Epoch 713/800
24/24 [==============================] - 0s 323us/step - loss: 0.0157
Epoch 714/800
24/24 [==============================] - 0s 426us/step - loss: 0.0147
Epoch 715/800
24/24 [==============================] - 0s 239us/step - loss: 0.0147
Epoch 716/800
24/24 [==============================] - 0s 246us/step - loss: 0.0141
Epoch 717/800
24/24 [==============================] - 0s 341us/step - loss: 0.0157
Epoch 718/800
24/24 [==============================] - 0s 222us/step - loss: 0.0161
Epoch 719/800
24/24 [==============================] - 0s 209us/step - loss: 0.0158
Epoch 720/800
24/24 [==============================] - 0s 271us/step - loss: 0.0156
Epoch 721/800
24/24 [==============================] - 0s 225us/step - loss: 0.0157
Epoch 722/800
24/24 [==============================] - 0s 314us/step - loss: 0.0154
Epoch 723/800
24/24 [==============================] - 0s 439us/step - loss: 0.0148
Epoch 724/800
24/24 [==============================] - 0s 277us/step - loss: 0.0152
Epoch 725/800
24/24 [==============================] - 0s 242us/step - loss: 0.0152
Epoch 726/800
24/24 [==============================] - 0s 286us/step - loss: 0.0152
Epoch 727/800
24/24 [==============================] - 0s 337us/step - loss: 0.0153
Epoch 728/800
24/24 [==============================] - 0s 278us/step - loss: 0.0148
Epoch 729/800
24/24 [==============================] - 0s 350us/step - loss: 0.0149
```

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Epoch 730/800
24/24 [==============================] - 0s 209us/step - loss: 0.0151
Epoch 731/800
24/24 [==============================] - 0s 229us/step - loss: 0.0152
Epoch 732/800
24/24 [==============================] - 0s 264us/step - loss: 0.0154
Epoch 733/800
24/24 [==============================] - 0s 226us/step - loss: 0.0154
Epoch 734/800
24/24 [==============================] - 0s 253us/step - loss: 0.0152
Epoch 735/800
24/24 [==============================] - 0s 485us/step - loss: 0.0148
Epoch 736/800
24/24 [==============================] - 0s 633us/step - loss: 0.0153
Epoch 737/800
24/24 [==============================] - 0s 237us/step - loss: 0.0152
Epoch 738/800
24/24 [==============================] - 0s 274us/step - loss: 0.0150
Epoch 739/800
24/24 [==============================] - 0s 212us/step - loss: 0.0150
Epoch 740/800
24/24 [==============================] - 0s 225us/step - loss: 0.0153
Epoch 741/800
24/24 [==============================] - 0s 200us/step - loss: 0.0162
Epoch 742/800
24/24 [==============================] - 0s 248us/step - loss: 0.0148
Epoch 743/800
24/24 [==============================] - 0s 196us/step - loss: 0.0145
Epoch 744/800
24/24 [==============================] - 0s 226us/step - loss: 0.0140
Epoch 745/800
24/24 [==============================] - 0s 279us/step - loss: 0.0152
Epoch 746/800
24/24 [==============================] - 0s 262us/step - loss: 0.0154
Epoch 747/800
24/24 [==============================] - 0s 323us/step - loss: 0.0157
Epoch 748/800
24/24 [==============================] - 0s 550us/step - loss: 0.0150
Epoch 749/800
24/24 [==============================] - 0s 224us/step - loss: 0.0155
Epoch 750/800
24/24 [==============================] - 0s 315us/step - loss: 0.0148
Epoch 751/800
24/24 [==============================] - 0s 262us/step - loss: 0.0148
Epoch 752/800
24/24 [==============================] - 0s 220us/step - loss: 0.0150
Epoch 753/800
24/24 [==============================] - 0s 366us/step - loss: 0.0161
Epoch 754/800
24/24 [==============================] - 0s 263us/step - loss: 0.0154
Epoch 755/800
24/24 [==============================] - 0s 314us/step - loss: 0.0160
Epoch 756/800
24/24 [==============================] - 0s 224us/step - loss: 0.0144
Epoch 757/800
24/24 [==============================] - 0s 263us/step - loss: 0.0137
Epoch 758/800
```

```
24/24 [==============================] - 0s 255us/step - loss: 0.0146
Epoch 759/800
24/24 [==============================] - 0s 235us/step - loss: 0.0150
Epoch 760/800
24/24 [==============================] - 0s 336us/step - loss: 0.0153
Epoch 761/800
24/24 [==============================] - 0s 280us/step - loss: 0.0152
Epoch 762/800
24/24 [==============================] - 0s 292us/step - loss: 0.0144
Epoch 763/800
24/24 [==============================] - 0s 276us/step - loss: 0.0156
Epoch 764/800
24/24 [==============================] - 0s 264us/step - loss: 0.0150
Epoch 765/800
24/24 [==============================] - 0s 271us/step - loss: 0.0158
Epoch 766/800
24/24 [==============================] - 0s 500us/step - loss: 0.0145
Epoch 767/800
24/24 [==============================] - 0s 289us/step - loss: 0.0136
Epoch 768/800
24/24 [==============================] - 0s 266us/step - loss: 0.0138
Epoch 769/800
24/24 [==============================] - 0s 348us/step - loss: 0.0145
Epoch 770/800
24/24 [==============================] - 0s 319us/step - loss: 0.0152
Epoch 771/800
24/24 [==============================] - 0s 261us/step - loss: 0.0160
Epoch 772/800
24/24 [==============================] - 0s 258us/step - loss: 0.0153
Epoch 773/800
24/24 [==============================] - 0s 414us/step - loss: 0.0159
Epoch 774/800
24/24 [==============================] - 0s 406us/step - loss: 0.0152
Epoch 775/800
24/24 [==============================] - 0s 310us/step - loss: 0.0158
Epoch 776/800
24/24 [==============================] - 0s 272us/step - loss: 0.0142
Epoch 777/800
24/24 [==============================] - 0s 295us/step - loss: 0.0149
Epoch 778/800
24/24 [==============================] - 0s 486us/step - loss: 0.0145
Epoch 779/800
24/24 [==============================] - 0s 283us/step - loss: 0.0149
Epoch 780/800
24/24 [==============================] - 0s 306us/step - loss: 0.0143
Epoch 781/800
24/24 [==============================] - 0s 262us/step - loss: 0.0155
Epoch 782/800
24/24 [==============================] - 0s 409us/step - loss: 0.0146
Epoch 783/800
24/24 [==============================] - 0s 262us/step - loss: 0.0153
Epoch 784/800
24/24 [==============================] - 0s 468us/step - loss: 0.0145
Epoch 785/800
24/24 [==============================] - 0s 306us/step - loss: 0.0152
Epoch 786/800
24/24 [==============================] - 0s 598us/step - loss: 0.0148
```

```
Epoch 787/800
24/24 [==============================] - 0s 652us/step - loss: 0.0148
Epoch 788/800
24/24 [==============================] - 0s 791us/step - loss: 0.0146
Epoch 789/800
24/24 [==============================] - 0s 621us/step - loss: 0.0157
Epoch 790/800
24/24 [==============================] - 0s 483us/step - loss: 0.0144
Epoch 791/800
24/24 [==============================] - 0s 300us/step - loss: 0.0144
Epoch 792/800
24/24 [==============================] - 0s 350us/step - loss: 0.0144
Epoch 793/800
24/24 [==============================] - 0s 233us/step - loss: 0.0152
Epoch 794/800
24/24 [==============================] - 0s 350us/step - loss: 0.0143
Epoch 795/800
24/24 [==============================] - 0s 236us/step - loss: 0.0145
Epoch 796/800
24/24 [==============================] - 0s 231us/step - loss: 0.0153
Epoch 797/800
24/24 [==============================] - 0s 246us/step - loss: 0.0154
Epoch 798/800
24/24 [==============================] - 0s 336us/step - loss: 0.0147
Epoch 799/800
24/24 [==============================] - 0s 299us/step - loss: 0.0147
Epoch 800/800
24/24 [==============================] - 0s 509us/step - loss: 0.0148
best epoch =  767
smallest loss = 0.013608266599476337
```

In [27]:

```
# Task 1.3 Part e
from sklearn import metrics

# This line of code can be used to reconstruct the saved model. The name of t
recon_model2 = keras.models.load_model("best_model2")

import matplotlib.pyplot as plt

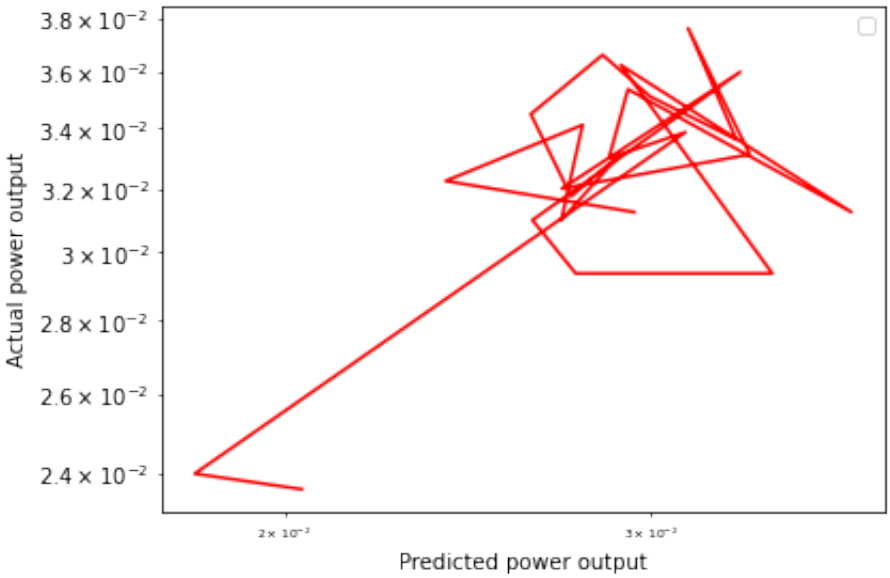
y_predict = []
Wdotpred = []
Wdotorig = []

for i in range(len(X_trainn)):
    test = [[X_trainn[i][0], X_trainn[i][1], X_trainn[i][2]]]
    testarray = np.array(test)
    a3 = recon_model2.predict(testarray)
    y_predict.append([a3[0][0], a3[0][1]])
    Wdotpred.append([a3[0][1]])
    Wdotorig.append([y_trainn[i][1]])

plt.figure()
plt.loglog(Wdotpred, Wdotorig, c='r')
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpred,Wdotorig)
mae_Vl = metrics.mean_absolute_error(y_predict[:][1],y_trainn[:][1])
print('mean absolute error between predictions and the collection of test dat
```

```
No handles with labels found to put in legend.
```




```
mean absolute error between predictions and the collection of test data: Vl =
0.10512211718410257  Wdot =  0.004687307881812254
```

In [28]:

```
# Task 1.3 Part f

# This line of code can be used to reconstruct the saved model. The name of t
recon_model2 = keras.models.load_model("best_model2")

import matplotlib.pyplot as plt

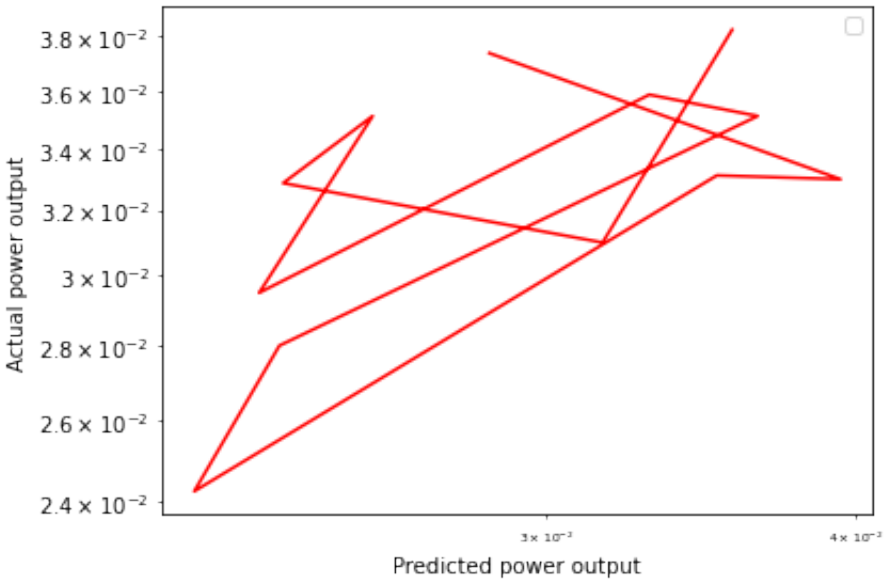
y_predictn = []
y_traino = []
Wdotpred2 = []
Wdotorig2 = []

for i in range(len(X_testn)):
    testn = [[X_testn[i][0], X_testn[i][1], X_testn[i][2]]]
    testarrayn = np.array(testn)
    a3 = recon_model2.predict(testarrayn)
    y_predictn.append([a3[0][0], a3[0][1]])
    Wdotpred2.append([a3[0][1]])
    y_traino.append([y_testn[i][0], y_testn[i][1]])
    Wdotorig2.append([y_testn[i][1]])

plt.figure()
plt.loglog(Wdotpred2, Wdotorig2, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpred2,Wdotorig2)
mae_Vl = metrics.mean_absolute_error(y_predictn[:][1],y_traino[:][1])
print('mean absolute error between predictions and the collection of test dat
```

```
No handles with labels found to put in legend.
```




```
mean absolute error between predictions and the collection of test data: Vl =
0.023546777188777915  Wdot =  0.004787884597977001
```

In [29]:

```
# Task 1.3 Part g

# This line of code can be used to reconstruct the saved model. The name of t
recon_model2 = keras.models.load_model("best_model2")

import matplotlib.pyplot as plt

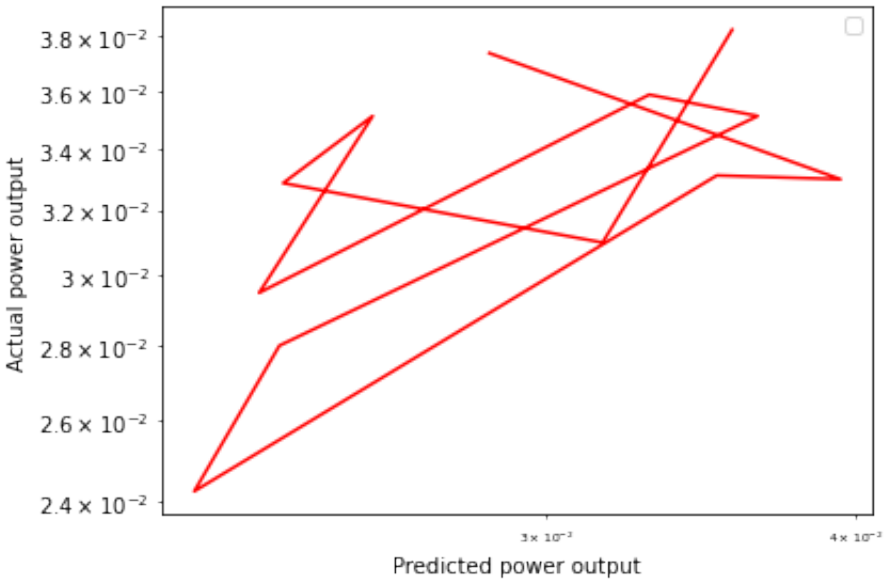
y_predicthn = []
y_train = []
Wdotpredh = []
Wdotorigh = []

for i in range(len(xarrayhn)):
    testhn = [[xarrayhn[i][0], xarrayhn[i][1], xarrayhn[i][2]]]
    testarrayhn = np.array(testhn)
    a3 = recon_model2.predict(testarrayhn)
    y_predicthn.append([a3[0][0], a3[0][1]])
    Wdotpredh.append([a3[0][1]])
    y_train.append([yarrayhn[i][0], yarrayhn[i][1]])
    Wdotorigh.append([yarrayhn[i][1]])

plt.figure()
plt.loglog(Wdotpred2, Wdotorig2, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(Wdotpredh,Wdotorigh)
mae_Vl = metrics.mean_absolute_error(y_predicthn[:][1],y_train[:][1])
print('mean absolute error between predictions and the collection of test dat
```

```
No handles with labels found to put in legend.
```




```
mean absolute error between predictions and the collection of test data: Vl =
2.2440235184724715  Wdot =  0.9700400130823255
```

In [30]:

```
#Task1.3 part h
import matplotlib.pyplot as plt
import numpy as np

fig = plt.figure()
ax = plt.axes(projection='3d')

X = np.linspace(500, 1800) #Id
Y = np.linspace(4, 8) #Rl
Zp = []
Xp = []
Yp = []
Tair = 20
testdata = []

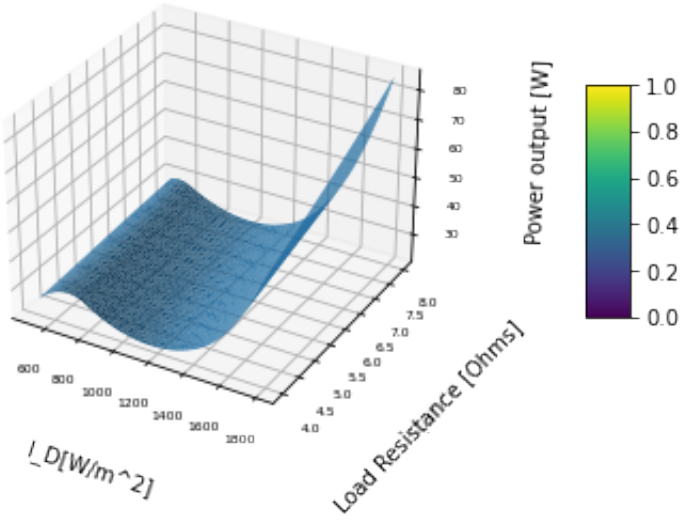
Tn = Tair/medTair
Xn = X/medId
Yn = Y/medRl

for x in range(len(Xn)):
    for y in range(len(Yn)):
        testdata.append([Tn, Xn[x], Yn[y]])
        Xp.append(Xn[x]*medId)
        Yp.append(Yn[y]*medRl)

for x in range(len(testdata)):
    test = [[testdata[x][0], testdata[x][1], testdata[x][2]]]
    testarray = np.array(test)
    outptn = recon_model2.predict(testarray)
    Zp.append(outptn[0][1]*medWdot)

surf = ax.plot_trisurf(Xp, Yp, Zp)
fig.colorbar(surf, shrink=0.5, aspect=5, pad=0.2)
ax.set_zlabel('Power output [W]', rotation=60)
ax.set_ylabel('Load Resistance [Ohms]')
ax.set_xlabel('I_D[W/m^2]', rotation=150)
ax.xaxis.labelpad=15
ax.yaxis.labelpad=15
ax.zaxis.labelpad=15

plt.show()
```



In [4]:

```
#Task2.1 Part a
import math, numpy
#Part 2 input data: Air temp (degC), ID (W/sqm), load resistance (ohms)
# - split into a training set and a small (~10) randomly selected validation

xdata = [[10.0, 200.0, 24.3],
 [10.0, 200.0, 51.8],
 [10.0, 200.0, 96.2],
 [10.0, 200.0, 133.2],
 [10.0, 200.0, 170.1],
 [10.0, 500.0, 7.0],
 [10.0, 500.0, 21.2],
 [10.0, 500.0, 43.2],
 [10.0, 500.0, 61.2],
 [10.0, 500.0, 79.1],
 [10.0, 700.0, 4.9],
 [10.0, 700.0, 14.3],
 [10.0, 700.0, 29.7],
 [10.0, 700.0, 42.9],
 [10.0, 700.0, 55.3],
 [10.0, 1000.0, 3.92],
 [10.0, 1000.0, 11.7],
 [10.0, 1000.0, 25.2],
 [10.0, 1000.0, 33.4],
 [10.0, 1000.0, 41.6],
 [18.1, 500.0, 7.0],
 [18.5, 500.0, 21.2],
 [19.0, 500.0, 43.2],
 [18.6, 500.0, 61.2],
 [18.8, 500.0, 79.1],
 [2.1, 1000.0, 3.92],
 [2.0, 1000.0, 11.7],
 [1.9, 1000.0, 25.2],
 [2.3, 1000.0, 33.4],
```

```
 [2.4, 1000.0, 41.6],
 [0.5, 700.0, 4.9],
 [0.7, 700.0, 14.3],
 [1.0, 700.0, 29.7],
 [0.8, 700.0, 42.9],
 [0.2, 700.0, 55.3],
 [15.2, 200.0, 24.3],
 [15.4, 200.0, 51.8],
 [21.2, 1000.0, 3.92],
 [19.4, 1000.0, 11.7],
 [19.2, 1000.0, 25.2]]



#Part 2 output data: Mode providing maximum power outp, VL (V) and Power out
ydata = [[1.0, 46.1, 87.1],
 [2.0, 92.1, 163.9],
 [3.0, 110.6, 127.2],
 [3.0, 147.5, 163.5],
 [3.0, 184.3, 199.7],
 [1.0, 48.4, 335.3],
 [2.0, 96.9, 442.9],
 [3.0, 128.7, 383.6],
 [3.0, 161.3, 429.2],
 [3.0, 193.8, 474.8],
 [1.0, 49.3, 496.1],
 [2.0, 98.6, 680.0],
 [3.0, 124.1, 518.9],
 [3.0, 160.7, 611.2],
 [3.0, 197.2, 703.4],
 [1.0, 50.8, 659.0],
 [2.0, 101.65, 883.1],
 [3.0, 148.7, 877.2],
 [3.0, 176.0, 935.4],
 [3.0, 203.3, 993.5],
 [1.0, 47.6, 327.0],
 [2.0, 96.1, 432.3],
 [3.0, 127.9, 374.4],
 [3.0, 160.5, 418.9],
 [3.0, 193.0, 463.4],
 [1.0, 50.0, 674.7],
 [2.0, 100.9, 904.3],
 [3.0, 147.9, 898.3],
 [3.0, 175.2, 957.8],
 [3.0, 202.4, 1017.3],
 [1.0, 50.3, 511.0],
 [2.0, 100.6, 700.4],
 [3.0, 125.1, 534.5],
 [3.0, 161.7, 629.5],
 [3.0, 198.2, 724.5],
 [1.0, 45.6, 85.8],
 [2.0, 91.5, 161.4],
 [1.0, 49.8, 639.2],
```

```
 [2.0, 100.6, 856.6],
 [3.0, 147.7, 850.9] ]

xarray= numpy.array(xdata)
yarray= numpy.array(ydata)

Mmaxm = []
Vlm = []
Wdotm = []
Tairm =[]
Idm =[]
Rlm =[]

for x in range(len(xarray)):
    Tairm.append(xarray[x][0])
    Idm.append(xarray[x][1])
    Rlm.append(xarray[x][2])

for y in range(len(yarray)):
    Mmaxm.append(yarray[y][0])
    Vlm.append(yarray[y][1])
    Wdotm.append(yarray[y][2])

medTairm = median(Tairm)
medIdm = median(Idm)
medRlm = median(Rlm)
medVlm = median(Vlm)
medWdotm = median(Wdotm)
medMmaxm = median(Mmaxm)

Tairmn = Tairm/medTairm
Idmn = Idm/medIdm
Rlmn = Rlm/medRlm
Vlmn = Vlm/medVlm
Wdotmn = Wdotm/medWdotm
Mmaxmn = Mmaxm/medMmaxm

xarraymn = np.column_stack((Tairmn, Idmn, Rlmn))
yarraymn = np.column_stack((Mmaxmn, Vlmn, Wdotmn))

print(xarraymn)
print(yarraymn)
```

```
[[1.         0.28571429 0.81818182]
 [1.         0.28571429 1.74410774]
 [1.         0.28571429 3.23905724]
 [1.         0.28571429 4.48484848]
 [1.         0.28571429 5.72727273]
 [1.         0.71428571 0.23569024]
 [1.         0.71428571 0.71380471]
 [1.         0.71428571 1.45454545]
 [1.         0.71428571 2.06060606]
 [1.         0.71428571 2.66329966]
 [1.         1.         0.16498316]
```

```
 [1.         1.         0.48148148]
 [1.         1.         1.        ]
 [1.         1.         1.44444444]
 [1.         1.         1.86195286]
 [1.         1.42857143 0.13198653]
 [1.         1.42857143 0.39393939]
 [1.         1.42857143 0.84848485]
 [1.         1.42857143 1.12457912]
 [1.         1.42857143 1.4006734 ]
 [1.81       0.71428571 0.23569024]
 [1.85       0.71428571 0.71380471]
 [1.9        0.71428571 1.45454545]
 [1.86       0.71428571 2.06060606]
 [1.88       0.71428571 2.66329966]
 [0.21       1.42857143 0.13198653]
 [0.2        1.42857143 0.39393939]
 [0.19       1.42857143 0.84848485]
 [0.23       1.42857143 1.12457912]
 [0.24       1.42857143 1.4006734 ]
 [0.05       1.         0.16498316]
 [0.07       1.         0.48148148]
 [0.1        1.         1.        ]
 [0.08       1.         1.44444444]
 [0.02       1.         1.86195286]
 [1.52       0.28571429 0.81818182]
 [1.54       0.28571429 1.74410774]
 [2.12       1.42857143 0.13198653]
 [1.94       1.42857143 0.39393939]
 [1.92       1.42857143 0.84848485]]
[[0.33333333 0.36998395 0.16536928]
 [0.66666667 0.73916533 0.31118284]
 [1.         0.88764045 0.2415037 ]
 [1.         1.18378812 0.31042339]
 [1.         1.47913323 0.37915322]
 [0.33333333 0.38844302 0.63660528]
 [0.66666667 0.7776886  0.84089615]
 [1.         1.0329053  0.72830833]
 [1.         1.29454254 0.81488513]
 [1.         1.55537721 0.90146193]
 [0.33333333 0.39566613 0.94190241]
 [0.66666667 0.79133226 1.29105753]
 [1.         0.99598716 0.98519081]
 [1.         1.28972713 1.16043288]
 [1.         1.58266453 1.3354851 ]
 [0.33333333 0.40770465 1.25118663]
 [0.66666667 0.81581059 1.67666603]
 [1.         1.19341894 1.66546421]
 [1.         1.41252006 1.77596355]
 [1.         1.63162119 1.88627302]
 [0.33333333 0.38202247 0.62084678]
 [0.66666667 0.77126806 0.82077084]
 [1.         1.02648475 0.71084109]
 [1.         1.28812199 0.79532941]
 [1.         1.54895666 0.87981773]
 [0.33333333 0.40128411 1.28099487]
 [0.66666667 0.80979133 1.71691665]
 [1.         1.18699839 1.70552497]
```

```
 [1.         1.40609952 1.8184925 ]
 [1.         1.62439807 1.93146003]
 [0.33333333 0.40369181 0.97019176]
 [0.66666667 0.80738363 1.32978925]
 [1.         1.00401284 1.01480919]
 [1.         1.29775281 1.19517752]
 [1.         1.59069021 1.37554585]
 [0.33333333 0.36597111 0.16290108]
 [0.66666667 0.73434992 0.3064363 ]
 [0.33333333 0.39967897 1.21359408]
 [0.66666667 0.80738363 1.62635276]
 [1.         1.18539326 1.61553066]]
```

In [5]:

```
#Task 2.1 Part b
from sklearn.model_selection import train_test_split

X_train2, X_test2, y_train2, y_test2 = train_test_split(xarraymn, yarraymn, t

print(X_train2)
print(y_train2)
print(X_test2)
print(y_test2)
```

```
[[0.21       1.42857143 0.13198653]
 [1.         0.71428571 2.66329966]
 [1.         1.         1.44444444]
 [0.07       1.         0.48148148]
 [0.02       1.         1.86195286]
 [1.         0.71428571 2.06060606]
 [1.         1.42857143 0.84848485]
 [1.88       0.71428571 2.66329966]
 [1.         0.28571429 0.81818182]
 [0.08       1.         1.44444444]
 [1.         0.71428571 0.23569024]
 [1.         1.         0.48148148]
 [1.         0.28571429 1.74410774]
 [0.24       1.42857143 1.4006734 ]
 [1.85       0.71428571 0.71380471]
 [1.         0.28571429 3.23905724]
 [0.05       1.         0.16498316]
 [1.54       0.28571429 1.74410774]
 [1.         0.28571429 4.48484848]
 [1.52       0.28571429 0.81818182]
 [1.86       0.71428571 2.06060606]
 [0.1        1.         1.        ]
 [1.         1.         0.16498316]
 [1.9        0.71428571 1.45454545]
 [1.         1.42857143 1.12457912]
 [1.81       0.71428571 0.23569024]
 [1.         0.71428571 1.45454545]
 [1.         1.         1.86195286]
 [0.23       1.42857143 1.12457912]
 [1.94       1.42857143 0.39393939]]
[[0.33333333 0.40128411 1.28099487]
 [1.         1.55537721 0.90146193]
```

```
 [1.         1.28972713 1.16043288]
 [0.66666667 0.80738363 1.32978925]
 [1.         1.59069021 1.37554585]
 [1.         1.29454254 0.81488513]
 [1.         1.19341894 1.66546421]
 [1.         1.54895666 0.87981773]
 [0.33333333 0.36998395 0.16536928]
 [1.         1.29775281 1.19517752]
 [0.33333333 0.38844302 0.63660528]
 [0.66666667 0.79133226 1.29105753]
 [0.66666667 0.73916533 0.31118284]
 [1.         1.62439807 1.93146003]
 [0.66666667 0.77126806 0.82077084]
 [1.         0.88764045 0.2415037 ]
 [0.33333333 0.40369181 0.97019176]
 [0.66666667 0.73434992 0.3064363 ]
 [1.         1.18378812 0.31042339]
 [0.33333333 0.36597111 0.16290108]
 [1.         1.28812199 0.79532941]
 [1.         1.00401284 1.01480919]
 [0.33333333 0.39566613 0.94190241]
 [1.         1.02648475 0.71084109]
 [1.         1.41252006 1.77596355]
 [0.33333333 0.38202247 0.62084678]
 [1.         1.0329053  0.72830833]
 [1.         1.58266453 1.3354851 ]
 [1.         1.40609952 1.8184925 ]
 [0.66666667 0.80738363 1.62635276]]
[[1.         1.42857143 1.4006734 ]
 [1.         1.42857143 0.39393939]
 [1.         1.42857143 0.13198653]
 [0.2        1.42857143 0.39393939]
 [1.         0.28571429 5.72727273]
 [1.         1.         1.        ]
 [2.12       1.42857143 0.13198653]
 [0.19       1.42857143 0.84848485]
 [1.92       1.42857143 0.84848485]
 [1.         0.71428571 0.71380471]]
[[1.         1.63162119 1.88627302]
 [0.66666667 0.81581059 1.67666603]
 [0.33333333 0.40770465 1.25118663]
 [0.66666667 0.80979133 1.71691665]
 [1.         1.47913323 0.37915322]
 [1.         0.99598716 0.98519081]
 [0.33333333 0.39967897 1.21359408]
 [1.         1.18699839 1.70552497]
 [1.         1.18539326 1.61553066]
 [0.66666667 0.7776886  0.84089615]]
```

In [257…

```
# define neural network model

from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

modelv3 = keras.Sequential([
    keras.layers.Dense(16, activation=K.elu, input_shape=[3],  kernel_initial
    keras.layers.Dense(32, activation=K.elu,  kernel_initializer=initializer)
    keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(16,  activation=K.elu, kernel_initializer=initializer)
    keras.layers.Dense(3, kernel_initializer=initializer)
  ])
```

In [269…

```
#from tf.keras import optimizers
rms = keras.optimizers.RMSprop(0.0001)
modelv3.compile(loss='mean_absolute_error',optimizer=rms)
```

In [272…

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 80,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model3.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = modelv3.fit(X_train2,y_train2,epochs=800,callbacks=[es])

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))

modelv3.save('./best_model3')
```

```
Epoch 1/800
30/30 [==============================] - 0s 311us/step - loss: 0.0279
Epoch 2/800
30/30 [==============================] - 0s 225us/step - loss: 0.0285
Epoch 3/800
30/30 [==============================] - 0s 276us/step - loss: 0.0283
Epoch 4/800
30/30 [==============================] - 0s 246us/step - loss: 0.0278
Epoch 5/800
30/30 [==============================] - 0s 186us/step - loss: 0.0277
Epoch 6/800
```

```
30/30 [==============================] - 0s 208us/step - loss: 0.0274
Epoch 7/800
30/30 [==============================] - 0s 204us/step - loss: 0.0279
Epoch 8/800
30/30 [==============================] - 0s 270us/step - loss: 0.0278
Epoch 9/800
30/30 [==============================] - 0s 267us/step - loss: 0.0272
Epoch 10/800
30/30 [==============================] - 0s 213us/step - loss: 0.0278
Epoch 11/800
30/30 [==============================] - 0s 287us/step - loss: 0.0290
Epoch 12/800
30/30 [==============================] - 0s 267us/step - loss: 0.0286
Epoch 13/800
30/30 [==============================] - 0s 261us/step - loss: 0.0279
Epoch 14/800
30/30 [==============================] - 0s 263us/step - loss: 0.0279
Epoch 15/800
30/30 [==============================] - 0s 273us/step - loss: 0.0278
Epoch 16/800
30/30 [==============================] - 0s 252us/step - loss: 0.0278
Epoch 17/800
30/30 [==============================] - 0s 673us/step - loss: 0.0281
Epoch 18/800
30/30 [==============================] - 0s 622us/step - loss: 0.0272
Epoch 19/800
30/30 [==============================] - 0s 390us/step - loss: 0.0270
Epoch 20/800
30/30 [==============================] - 0s 188us/step - loss: 0.0273
Epoch 21/800
30/30 [==============================] - 0s 227us/step - loss: 0.0272
Epoch 22/800
30/30 [==============================] - 0s 188us/step - loss: 0.0277
Epoch 23/800
30/30 [==============================] - 0s 217us/step - loss: 0.0279
Epoch 24/800
30/30 [==============================] - 0s 254us/step - loss: 0.0286
Epoch 25/800
30/30 [==============================] - 0s 193us/step - loss: 0.0283
Epoch 26/800
30/30 [==============================] - 0s 205us/step - loss: 0.0292
Epoch 27/800
30/30 [==============================] - 0s 224us/step - loss: 0.0284
Epoch 28/800
30/30 [==============================] - 0s 213us/step - loss: 0.0284
Epoch 29/800
30/30 [==============================] - 0s 204us/step - loss: 0.0278
Epoch 30/800
30/30 [==============================] - 0s 348us/step - loss: 0.0275
Epoch 31/800
30/30 [==============================] - 0s 533us/step - loss: 0.0278
Epoch 32/800
30/30 [==============================] - 0s 310us/step - loss: 0.0270
Epoch 33/800
30/30 [==============================] - 0s 175us/step - loss: 0.0269
Epoch 34/800
30/30 [==============================] - 0s 183us/step - loss: 0.0275
```

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Epoch 35/800
30/30 [==============================] - 0s 212us/step - loss: 0.0283
Epoch 36/800
30/30 [==============================] - 0s 181us/step - loss: 0.0287
Epoch 37/800
30/30 [==============================] - 0s 171us/step - loss: 0.0278
Epoch 38/800
30/30 [==============================] - 0s 193us/step - loss: 0.0296
Epoch 39/800
30/30 [==============================] - 0s 161us/step - loss: 0.0282
Epoch 40/800
30/30 [==============================] - 0s 172us/step - loss: 0.0284
Epoch 41/800
30/30 [==============================] - 0s 160us/step - loss: 0.0277
Epoch 42/800
30/30 [==============================] - 0s 157us/step - loss: 0.0278
Epoch 43/800
30/30 [==============================] - 0s 196us/step - loss: 0.0284
Epoch 44/800
30/30 [==============================] - 0s 271us/step - loss: 0.0281
Epoch 45/800
30/30 [==============================] - 0s 227us/step - loss: 0.0277
Epoch 46/800
30/30 [==============================] - 0s 210us/step - loss: 0.0274
Epoch 47/800
30/30 [==============================] - 0s 185us/step - loss: 0.0272
Epoch 48/800
30/30 [==============================] - 0s 179us/step - loss: 0.0269
Epoch 49/800
30/30 [==============================] - 0s 157us/step - loss: 0.0274
Epoch 50/800
30/30 [==============================] - 0s 204us/step - loss: 0.0274
Epoch 51/800
30/30 [==============================] - 0s 160us/step - loss: 0.0277
Epoch 52/800
30/30 [==============================] - 0s 184us/step - loss: 0.0278
Epoch 53/800
30/30 [==============================] - 0s 165us/step - loss: 0.0287
Epoch 54/800
30/30 [==============================] - 0s 167us/step - loss: 0.0287
Epoch 55/800
30/30 [==============================] - 0s 160us/step - loss: 0.0278
Epoch 56/800
30/30 [==============================] - 0s 163us/step - loss: 0.0290
Epoch 57/800
30/30 [==============================] - 0s 159us/step - loss: 0.0277
Epoch 58/800
30/30 [==============================] - 0s 161us/step - loss: 0.0275
Epoch 59/800
30/30 [==============================] - 0s 181us/step - loss: 0.0278
Epoch 60/800
30/30 [==============================] - 0s 275us/step - loss: 0.0278
Epoch 61/800
30/30 [==============================] - 0s 414us/step - loss: 0.0269
Epoch 62/800
30/30 [==============================] - 0s 152us/step - loss: 0.0269
Epoch 63/800
```

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30/30 [==============================] - 0s 214us/step - loss: 0.0273
Epoch 64/800
30/30 [==============================] - 0s 176us/step - loss: 0.0279
Epoch 65/800
30/30 [==============================] - 0s 202us/step - loss: 0.0285
Epoch 66/800
30/30 [==============================] - 0s 167us/step - loss: 0.0286
Epoch 67/800
30/30 [==============================] - 0s 188us/step - loss: 0.0292
Epoch 68/800
30/30 [==============================] - 0s 166us/step - loss: 0.0284
Epoch 69/800
30/30 [==============================] - 0s 199us/step - loss: 0.0282
Epoch 70/800
30/30 [==============================] - 0s 163us/step - loss: 0.0276
Epoch 71/800
30/30 [==============================] - 0s 186us/step - loss: 0.0273
Epoch 72/800
30/30 [==============================] - 0s 187us/step - loss: 0.0276
Epoch 73/800
30/30 [==============================] - 0s 189us/step - loss: 0.0269
Epoch 74/800
30/30 [==============================] - 0s 186us/step - loss: 0.0269
Epoch 75/800
30/30 [==============================] - 0s 173us/step - loss: 0.0277
Epoch 76/800
30/30 [==============================] - 0s 201us/step - loss: 0.0282
Epoch 77/800
30/30 [==============================] - 0s 280us/step - loss: 0.0282
Epoch 78/800
30/30 [==============================] - 0s 325us/step - loss: 0.0281
Epoch 79/800
30/30 [==============================] - 0s 409us/step - loss: 0.0290
Epoch 80/800
30/30 [==============================] - 0s 519us/step - loss: 0.0277
Epoch 81/800
30/30 [==============================] - 0s 298us/step - loss: 0.0279
Epoch 82/800
30/30 [==============================] - 0s 346us/step - loss: 0.0277
Epoch 83/800
30/30 [==============================] - 0s 315us/step - loss: 0.0276
Epoch 84/800
30/30 [==============================] - 0s 309us/step - loss: 0.0278
Epoch 85/800
30/30 [==============================] - 0s 278us/step - loss: 0.0272
Epoch 86/800
30/30 [==============================] - 0s 168us/step - loss: 0.0273
Epoch 87/800
30/30 [==============================] - 0s 204us/step - loss: 0.0274
Epoch 88/800
30/30 [==============================] - 0s 186us/step - loss: 0.0284
Epoch 89/800
30/30 [==============================] - 0s 194us/step - loss: 0.0290
Epoch 90/800
30/30 [==============================] - 0s 247us/step - loss: 0.0279
Epoch 91/800
30/30 [==============================] - 0s 278us/step - loss: 0.0281
```

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Epoch 92/800
30/30 [==============================] - 0s 214us/step - loss: 0.0282
Epoch 93/800
30/30 [==============================] - 0s 242us/step - loss: 0.0280
Epoch 94/800
30/30 [==============================] - 0s 142us/step - loss: 0.0278
Epoch 95/800
30/30 [==============================] - 0s 168us/step - loss: 0.0276
Epoch 96/800
30/30 [==============================] - 0s 206us/step - loss: 0.0281
Epoch 97/800
30/30 [==============================] - 0s 209us/step - loss: 0.0272
Epoch 98/800
30/30 [==============================] - 0s 193us/step - loss: 0.0273
Epoch 99/800
30/30 [==============================] - 0s 232us/step - loss: 0.0281
Epoch 100/800
30/30 [==============================] - 0s 156us/step - loss: 0.0275
Epoch 101/800
30/30 [==============================] - 0s 235us/step - loss: 0.0275
Epoch 102/800
30/30 [==============================] - 0s 208us/step - loss: 0.0275
Epoch 103/800
30/30 [==============================] - 0s 353us/step - loss: 0.0281
Epoch 104/800
30/30 [==============================] - 0s 282us/step - loss: 0.0289
Epoch 105/800
30/30 [==============================] - 0s 201us/step - loss: 0.0282
Epoch 106/800
30/30 [==============================] - 0s 215us/step - loss: 0.0278
Epoch 107/800
30/30 [==============================] - 0s 237us/step - loss: 0.0285
Epoch 108/800
30/30 [==============================] - 0s 241us/step - loss: 0.0278
Epoch 109/800
30/30 [==============================] - 0s 182us/step - loss: 0.0273
Epoch 110/800
30/30 [==============================] - 0s 258us/step - loss: 0.0273
Epoch 111/800
30/30 [==============================] - 0s 231us/step - loss: 0.0267
Epoch 112/800
30/30 [==============================] - 0s 231us/step - loss: 0.0268
Epoch 113/800
30/30 [==============================] - 0s 221us/step - loss: 0.0270
Epoch 114/800
30/30 [==============================] - 0s 211us/step - loss: 0.0281
Epoch 115/800
30/30 [==============================] - 0s 326us/step - loss: 0.0278
Epoch 116/800
30/30 [==============================] - 0s 208us/step - loss: 0.0288
Epoch 117/800
30/30 [==============================] - 0s 197us/step - loss: 0.0281
Epoch 118/800
30/30 [==============================] - 0s 182us/step - loss: 0.0292
Epoch 119/800
30/30 [==============================] - 0s 219us/step - loss: 0.0282
Epoch 120/800
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30/30 [==============================] - 0s 204us/step - loss: 0.0284
Epoch 121/800
30/30 [==============================] - 0s 186us/step - loss: 0.0275
Epoch 122/800
30/30 [==============================] - 0s 196us/step - loss: 0.0272
Epoch 123/800
30/30 [==============================] - 0s 198us/step - loss: 0.0271
Epoch 124/800
30/30 [==============================] - 0s 187us/step - loss: 0.0272
Epoch 125/800
30/30 [==============================] - 0s 184us/step - loss: 0.0280
Epoch 126/800
30/30 [==============================] - 0s 298us/step - loss: 0.0280
Epoch 127/800
30/30 [==============================] - 0s 177us/step - loss: 0.0281
Epoch 128/800
30/30 [==============================] - 0s 183us/step - loss: 0.0288
Epoch 129/800
30/30 [==============================] - 0s 209us/step - loss: 0.0281
Epoch 130/800
30/30 [==============================] - 0s 172us/step - loss: 0.0279
Epoch 131/800
30/30 [==============================] - 0s 232us/step - loss: 0.0275
Epoch 132/800
30/30 [==============================] - 0s 220us/step - loss: 0.0278
Epoch 133/800
30/30 [==============================] - 0s 387us/step - loss: 0.0279
Epoch 134/800
30/30 [==============================] - 0s 214us/step - loss: 0.0270
Epoch 135/800
30/30 [==============================] - 0s 158us/step - loss: 0.0267
Epoch 136/800
30/30 [==============================] - 0s 162us/step - loss: 0.0273
Epoch 137/800
30/30 [==============================] - 0s 155us/step - loss: 0.0274
Epoch 138/800
30/30 [==============================] - 0s 201us/step - loss: 0.0283
Epoch 139/800
30/30 [==============================] - 0s 315us/step - loss: 0.0277
Epoch 140/800
30/30 [==============================] - 0s 186us/step - loss: 0.0285
Epoch 141/800
30/30 [==============================] - 0s 290us/step - loss: 0.0273
Epoch 142/800
30/30 [==============================] - 0s 219us/step - loss: 0.0272
Epoch 143/800
30/30 [==============================] - 0s 258us/step - loss: 0.0275
Epoch 144/800
30/30 [==============================] - 0s 205us/step - loss: 0.0274
Epoch 145/800
30/30 [==============================] - 0s 174us/step - loss: 0.0269
Epoch 146/800
30/30 [==============================] - 0s 180us/step - loss: 0.0281
Epoch 147/800
30/30 [==============================] - 0s 194us/step - loss: 0.0292
Epoch 148/800
30/30 [==============================] - 0s 251us/step - loss: 0.0281
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Epoch 149/800
30/30 [==============================] - 0s 210us/step - loss: 0.0283
Epoch 150/800
30/30 [==============================] - 0s 220us/step - loss: 0.0284
Epoch 151/800
30/30 [==============================] - 0s 214us/step - loss: 0.0282
Epoch 152/800
30/30 [==============================] - 0s 260us/step - loss: 0.0278
Epoch 153/800
30/30 [==============================] - 0s 557us/step - loss: 0.0275
Epoch 154/800
30/30 [==============================] - 0s 436us/step - loss: 0.0269
Epoch 155/800
30/30 [==============================] - 0s 346us/step - loss: 0.0271
Epoch 156/800
30/30 [==============================] - 0s 404us/step - loss: 0.0275
Epoch 157/800
30/30 [==============================] - 0s 304us/step - loss: 0.0281
Epoch 158/800
30/30 [==============================] - 0s 324us/step - loss: 0.0272
Epoch 159/800
30/30 [==============================] - 0s 193us/step - loss: 0.0269
Epoch 160/800
30/30 [==============================] - 0s 313us/step - loss: 0.0273
Epoch 161/800
30/30 [==============================] - 0s 270us/step - loss: 0.0280
Epoch 162/800
30/30 [==============================] - 0s 299us/step - loss: 0.0286
Epoch 163/800
30/30 [==============================] - 0s 282us/step - loss: 0.0277
Epoch 164/800
30/30 [==============================] - 0s 406us/step - loss: 0.0276
Epoch 165/800
30/30 [==============================] - 0s 318us/step - loss: 0.0271
Epoch 166/800
30/30 [==============================] - 0s 302us/step - loss: 0.0272
Epoch 167/800
30/30 [==============================] - 0s 442us/step - loss: 0.0269
Epoch 168/800
30/30 [==============================] - 0s 315us/step - loss: 0.0270
Epoch 169/800
30/30 [==============================] - 0s 308us/step - loss: 0.0269
Epoch 170/800
30/30 [==============================] - 0s 414us/step - loss: 0.0274
Epoch 171/800
30/30 [==============================] - 0s 224us/step - loss: 0.0272
Epoch 172/800
30/30 [==============================] - 0s 245us/step - loss: 0.0294
Epoch 173/800
30/30 [==============================] - 0s 143us/step - loss: 0.0289
Epoch 174/800
30/30 [==============================] - 0s 202us/step - loss: 0.0293
Epoch 175/800
30/30 [==============================] - 0s 186us/step - loss: 0.0279
Epoch 176/800
30/30 [==============================] - 0s 150us/step - loss: 0.0279
Epoch 177/800
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30/30 [==============================] - 0s 184us/step - loss: 0.0284
Epoch 178/800
30/30 [==============================] - 0s 169us/step - loss: 0.0279
Epoch 179/800
30/30 [==============================] - 0s 225us/step - loss: 0.0276
Epoch 180/800
30/30 [==============================] - 0s 155us/step - loss: 0.0275
Epoch 181/800
30/30 [==============================] - 0s 142us/step - loss: 0.0272
Epoch 182/800
30/30 [==============================] - 0s 183us/step - loss: 0.0270
Epoch 183/800
30/30 [==============================] - 0s 311us/step - loss: 0.0271
Epoch 184/800
30/30 [==============================] - 0s 307us/step - loss: 0.0277
Epoch 185/800
30/30 [==============================] - 0s 251us/step - loss: 0.0275
Epoch 186/800
30/30 [==============================] - 0s 170us/step - loss: 0.0279
Epoch 187/800
30/30 [==============================] - 0s 254us/step - loss: 0.0285
Epoch 188/800
30/30 [==============================] - 0s 216us/step - loss: 0.0283
Epoch 189/800
30/30 [==============================] - 0s 202us/step - loss: 0.0283
Epoch 190/800
30/30 [==============================] - 0s 191us/step - loss: 0.0278
Epoch 191/800
30/30 [==============================] - 0s 225us/step - loss: 0.0277
Epoch 192/800
30/30 [==============================] - 0s 149us/step - loss: 0.0278
Epoch 193/800
30/30 [==============================] - 0s 232us/step - loss: 0.0267
Epoch 194/800
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Epoch 195/800
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Epoch 196/800
30/30 [==============================] - 0s 176us/step - loss: 0.0275
Epoch 197/800
30/30 [==============================] - 0s 179us/step - loss: 0.0277
Epoch 198/800
30/30 [==============================] - 0s 221us/step - loss: 0.0275
Epoch 199/800
30/30 [==============================] - 0s 295us/step - loss: 0.0277
Epoch 200/800
30/30 [==============================] - 0s 306us/step - loss: 0.0277
Epoch 201/800
30/30 [==============================] - 0s 204us/step - loss: 0.0286
Epoch 202/800
30/30 [==============================] - 0s 203us/step - loss: 0.0274
Epoch 203/800
30/30 [==============================] - 0s 170us/step - loss: 0.0273
Epoch 204/800
30/30 [==============================] - 0s 165us/step - loss: 0.0274
Epoch 205/800
30/30 [==============================] - 0s 190us/step - loss: 0.0273
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Epoch 206/800
30/30 [==============================] - 0s 199us/step - loss: 0.0275
Epoch 207/800
30/30 [==============================] - 0s 171us/step - loss: 0.0274
Epoch 208/800
30/30 [==============================] - 0s 159us/step - loss: 0.0268
Epoch 209/800
30/30 [==============================] - 0s 217us/step - loss: 0.0278
Epoch 210/800
30/30 [==============================] - 0s 193us/step - loss: 0.0288
Epoch 211/800
30/30 [==============================] - 0s 166us/step - loss: 0.0282
Epoch 212/800
30/30 [==============================] - 0s 189us/step - loss: 0.0275
Epoch 213/800
30/30 [==============================] - 0s 209us/step - loss: 0.0286
Epoch 214/800
30/30 [==============================] - 0s 202us/step - loss: 0.0281
Epoch 215/800
30/30 [==============================] - 0s 309us/step - loss: 0.0279
Epoch 216/800
30/30 [==============================] - 0s 173us/step - loss: 0.0277
Epoch 217/800
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Epoch 218/800
30/30 [==============================] - 0s 242us/step - loss: 0.0273
Epoch 219/800
30/30 [==============================] - 0s 182us/step - loss: 0.0267
Epoch 220/800
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Epoch 221/800
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Epoch 222/800
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Epoch 223/800
30/30 [==============================] - 0s 189us/step - loss: 0.0271
Epoch 224/800
30/30 [==============================] - 0s 186us/step - loss: 0.0277
Epoch 225/800
30/30 [==============================] - 0s 166us/step - loss: 0.0296
Epoch 226/800
30/30 [==============================] - 0s 280us/step - loss: 0.0281
Epoch 227/800
30/30 [==============================] - 0s 377us/step - loss: 0.0277
Epoch 228/800
30/30 [==============================] - 0s 241us/step - loss: 0.0278
Epoch 229/800
30/30 [==============================] - 0s 346us/step - loss: 0.0282
Epoch 230/800
30/30 [==============================] - 0s 211us/step - loss: 0.0273
Epoch 231/800
30/30 [==============================] - 0s 309us/step - loss: 0.0277
Epoch 232/800
30/30 [==============================] - 0s 302us/step - loss: 0.0272
Epoch 233/800
30/30 [==============================] - 0s 280us/step - loss: 0.0274
Epoch 234/800
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30/30 [==============================] - 0s 367us/step - loss: 0.0266
Epoch 235/800
30/30 [==============================] - 0s 265us/step - loss: 0.0266
Epoch 236/800
30/30 [==============================] - 0s 593us/step - loss: 0.0272
Epoch 237/800
30/30 [==============================] - 0s 440us/step - loss: 0.0273
Epoch 238/800
30/30 [==============================] - 0s 883us/step - loss: 0.0281
Epoch 239/800
30/30 [==============================] - 0s 437us/step - loss: 0.0278
Epoch 240/800
30/30 [==============================] - 0s 399us/step - loss: 0.0287
Epoch 241/800
30/30 [==============================] - 0s 321us/step - loss: 0.0291
Epoch 242/800
30/30 [==============================] - 0s 192us/step - loss: 0.0277
Epoch 243/800
30/30 [==============================] - 0s 339us/step - loss: 0.0274
Epoch 244/800
30/30 [==============================] - 0s 313us/step - loss: 0.0273
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30/30 [==============================] - 0s 189us/step - loss: 0.0272
Epoch 246/800
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Epoch 247/800
30/30 [==============================] - 0s 168us/step - loss: 0.0272
Epoch 248/800
30/30 [==============================] - 0s 211us/step - loss: 0.0273
Epoch 249/800
30/30 [==============================] - 0s 355us/step - loss: 0.0265
Epoch 250/800
30/30 [==============================] - 0s 136us/step - loss: 0.0271
Epoch 251/800
30/30 [==============================] - 0s 153us/step - loss: 0.0274
Epoch 252/800
30/30 [==============================] - 0s 235us/step - loss: 0.0297
Epoch 253/800
30/30 [==============================] - 0s 168us/step - loss: 0.0284
Epoch 254/800
30/30 [==============================] - 0s 193us/step - loss: 0.0282
Epoch 255/800
30/30 [==============================] - 0s 164us/step - loss: 0.0275
Epoch 256/800
30/30 [==============================] - 0s 164us/step - loss: 0.0283
Epoch 257/800
30/30 [==============================] - 0s 181us/step - loss: 0.0280
Epoch 258/800
30/30 [==============================] - 0s 158us/step - loss: 0.0277
Epoch 259/800
30/30 [==============================] - 0s 166us/step - loss: 0.0271
Epoch 260/800
30/30 [==============================] - 0s 212us/step - loss: 0.0268
Epoch 261/800
30/30 [==============================] - 0s 152us/step - loss: 0.0266
Epoch 262/800
30/30 [==============================] - 0s 211us/step - loss: 0.0267
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Epoch 263/800
30/30 [==============================] - 0s 175us/step - loss: 0.0269
Epoch 264/800
30/30 [==============================] - 0s 195us/step - loss: 0.0273
Epoch 265/800
30/30 [==============================] - 0s 260us/step - loss: 0.0267
Epoch 266/800
30/30 [==============================] - 0s 217us/step - loss: 0.0266
Epoch 267/800
30/30 [==============================] - 0s 157us/step - loss: 0.0274
Epoch 268/800
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Epoch 269/800
30/30 [==============================] - 0s 204us/step - loss: 0.0284
Epoch 270/800
30/30 [==============================] - 0s 179us/step - loss: 0.0280
Epoch 271/800
30/30 [==============================] - 0s 179us/step - loss: 0.0285
Epoch 272/800
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Epoch 273/800
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Epoch 274/800
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Epoch 275/800
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Epoch 276/800
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Epoch 277/800
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Epoch 278/800
30/30 [==============================] - 0s 212us/step - loss: 0.0274
Epoch 279/800
30/30 [==============================] - 0s 173us/step - loss: 0.0265
Epoch 280/800
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Epoch 281/800
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Epoch 282/800
30/30 [==============================] - 0s 159us/step - loss: 0.0274
Epoch 283/800
30/30 [==============================] - 0s 153us/step - loss: 0.0282
Epoch 284/800
30/30 [==============================] - 0s 148us/step - loss: 0.0286
Epoch 285/800
30/30 [==============================] - 0s 263us/step - loss: 0.0279
Epoch 286/800
30/30 [==============================] - 0s 232us/step - loss: 0.0279
Epoch 287/800
30/30 [==============================] - 0s 212us/step - loss: 0.0282
Epoch 288/800
30/30 [==============================] - 0s 257us/step - loss: 0.0279
Epoch 289/800
30/30 [==============================] - 0s 327us/step - loss: 0.0277
Epoch 290/800
30/30 [==============================] - 0s 472us/step - loss: 0.0272
Epoch 291/800
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30/30 [==============================] - 0s 485us/step - loss: 0.0274
Epoch 292/800
30/30 [==============================] - 0s 306us/step - loss: 0.0268
Epoch 293/800
30/30 [==============================] - 0s 418us/step - loss: 0.0271
Epoch 294/800
30/30 [==============================] - 0s 322us/step - loss: 0.0265
Epoch 295/800
30/30 [==============================] - 0s 171us/step - loss: 0.0269
Epoch 296/800
30/30 [==============================] - 0s 252us/step - loss: 0.0277
Epoch 297/800
30/30 [==============================] - 0s 212us/step - loss: 0.0282
Epoch 298/800
30/30 [==============================] - 0s 226us/step - loss: 0.0272
Epoch 299/800
30/30 [==============================] - 0s 222us/step - loss: 0.0281
Epoch 300/800
30/30 [==============================] - 0s 237us/step - loss: 0.0289
Epoch 301/800
30/30 [==============================] - 0s 311us/step - loss: 0.0278
Epoch 302/800
30/30 [==============================] - 0s 184us/step - loss: 0.0277
Epoch 303/800
30/30 [==============================] - 0s 223us/step - loss: 0.0283
Epoch 304/800
30/30 [==============================] - 0s 276us/step - loss: 0.0277
Epoch 305/800
30/30 [==============================] - 0s 217us/step - loss: 0.0273
Epoch 306/800
30/30 [==============================] - 0s 193us/step - loss: 0.0270
Epoch 307/800
30/30 [==============================] - 0s 219us/step - loss: 0.0269
Epoch 308/800
30/30 [==============================] - 0s 172us/step - loss: 0.0268
Epoch 309/800
30/30 [==============================] - 0s 170us/step - loss: 0.0270
Epoch 310/800
30/30 [==============================] - 0s 185us/step - loss: 0.0264
Epoch 311/800
30/30 [==============================] - 0s 524us/step - loss: 0.0267
Epoch 312/800
30/30 [==============================] - 0s 172us/step - loss: 0.0271
Epoch 313/800
30/30 [==============================] - 0s 231us/step - loss: 0.0271
Epoch 314/800
30/30 [==============================] - 0s 180us/step - loss: 0.0279
Epoch 315/800
30/30 [==============================] - 0s 205us/step - loss: 0.0288
Epoch 316/800
30/30 [==============================] - 0s 191us/step - loss: 0.0284
Epoch 317/800
30/30 [==============================] - 0s 188us/step - loss: 0.0285
Epoch 318/800
30/30 [==============================] - 0s 153us/step - loss: 0.0279
Epoch 319/800
30/30 [==============================] - 0s 246us/step - loss: 0.0275
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Epoch 320/800
30/30 [==============================] - 0s 213us/step - loss: 0.0279
Epoch 321/800
30/30 [==============================] - 0s 229us/step - loss: 0.0272
Epoch 322/800
30/30 [==============================] - 0s 265us/step - loss: 0.0271
Epoch 323/800
30/30 [==============================] - 0s 159us/step - loss: 0.0271
Epoch 324/800
30/30 [==============================] - 0s 489us/step - loss: 0.0270
Epoch 325/800
30/30 [==============================] - 0s 163us/step - loss: 0.0270
Epoch 326/800
30/30 [==============================] - 0s 237us/step - loss: 0.0276
Epoch 327/800
30/30 [==============================] - 0s 171us/step - loss: 0.0281
Epoch 328/800
30/30 [==============================] - 0s 191us/step - loss: 0.0281
Epoch 329/800
30/30 [==============================] - 0s 170us/step - loss: 0.0284
Epoch 330/800
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Epoch 331/800
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Epoch 333/800
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Epoch 341/800
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Epoch 342/800
30/30 [==============================] - 0s 192us/step - loss: 0.0278
Epoch 343/800
30/30 [==============================] - 0s 162us/step - loss: 0.0282
Epoch 344/800
30/30 [==============================] - 0s 251us/step - loss: 0.0279
Epoch 345/800
30/30 [==============================] - 0s 242us/step - loss: 0.0274
Epoch 346/800
30/30 [==============================] - 0s 262us/step - loss: 0.0279
Epoch 347/800
30/30 [==============================] - 0s 327us/step - loss: 0.0270
Epoch 348/800
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30/30 [==============================] - 0s 302us/step - loss: 0.0270
Epoch 349/800
30/30 [==============================] - 0s 261us/step - loss: 0.0265
Epoch 350/800
30/30 [==============================] - 0s 303us/step - loss: 0.0266
Epoch 351/800
30/30 [==============================] - 0s 364us/step - loss: 0.0265
Epoch 352/800
30/30 [==============================] - 0s 310us/step - loss: 0.0272
Epoch 353/800
30/30 [==============================] - 0s 362us/step - loss: 0.0278
Epoch 354/800
30/30 [==============================] - 0s 300us/step - loss: 0.0286
Epoch 355/800
30/30 [==============================] - 0s 210us/step - loss: 0.0288
Epoch 356/800
30/30 [==============================] - 0s 204us/step - loss: 0.0276
Epoch 357/800
30/30 [==============================] - 0s 185us/step - loss: 0.0272
Epoch 358/800
30/30 [==============================] - 0s 182us/step - loss: 0.0274
Epoch 359/800
30/30 [==============================] - 0s 164us/step - loss: 0.0276
Epoch 360/800
30/30 [==============================] - 0s 154us/step - loss: 0.0269
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Epoch 362/800
30/30 [==============================] - 0s 184us/step - loss: 0.0269
Epoch 363/800
30/30 [==============================] - 0s 156us/step - loss: 0.0276
Epoch 364/800
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Epoch 365/800
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Epoch 366/800
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Epoch 367/800
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Epoch 368/800
30/30 [==============================] - 0s 184us/step - loss: 0.0266
Epoch 369/800
30/30 [==============================] - 0s 166us/step - loss: 0.0269
Epoch 370/800
30/30 [==============================] - 0s 206us/step - loss: 0.0264
Epoch 371/800
30/30 [==============================] - 0s 145us/step - loss: 0.0265
Epoch 372/800
30/30 [==============================] - 0s 215us/step - loss: 0.0268
Epoch 373/800
30/30 [==============================] - 0s 224us/step - loss: 0.0273
Epoch 374/800
30/30 [==============================] - 0s 164us/step - loss: 0.0263
Epoch 375/800
30/30 [==============================] - 0s 190us/step - loss: 0.0268
Epoch 376/800
30/30 [==============================] - 0s 187us/step - loss: 0.0277
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Epoch 377/800
30/30 [==============================] - 0s 169us/step - loss: 0.0281
Epoch 378/800
30/30 [==============================] - 0s 183us/step - loss: 0.0284
Epoch 379/800
30/30 [==============================] - 0s 171us/step - loss: 0.0285
Epoch 380/800
30/30 [==============================] - 0s 193us/step - loss: 0.0282
Epoch 381/800
30/30 [==============================] - 0s 190us/step - loss: 0.0278
Epoch 382/800
30/30 [==============================] - 0s 183us/step - loss: 0.0275
Epoch 383/800
30/30 [==============================] - 0s 180us/step - loss: 0.0279
Epoch 384/800
30/30 [==============================] - 0s 156us/step - loss: 0.0271
Epoch 385/800
30/30 [==============================] - 0s 170us/step - loss: 0.0272
Epoch 386/800
30/30 [==============================] - 0s 163us/step - loss: 0.0270
Epoch 387/800
30/30 [==============================] - 0s 188us/step - loss: 0.0272
Epoch 388/800
30/30 [==============================] - 0s 179us/step - loss: 0.0270
Epoch 389/800
30/30 [==============================] - 0s 190us/step - loss: 0.0268
Epoch 390/800
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Epoch 391/800
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Epoch 395/800
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Epoch 396/800
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Epoch 397/800
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Epoch 398/800
30/30 [==============================] - 0s 187us/step - loss: 0.0270
Epoch 399/800
30/30 [==============================] - 0s 205us/step - loss: 0.0270
Epoch 400/800
30/30 [==============================] - 0s 198us/step - loss: 0.0276
Epoch 401/800
30/30 [==============================] - 0s 154us/step - loss: 0.0268
Epoch 402/800
30/30 [==============================] - 0s 215us/step - loss: 0.0272
Epoch 403/800
30/30 [==============================] - 0s 188us/step - loss: 0.0270
Epoch 404/800
30/30 [==============================] - 0s 177us/step - loss: 0.0263
Epoch 405/800
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30/30 [==============================] - 0s 139us/step - loss: 0.0275
Epoch 406/800
30/30 [==============================] - 0s 166us/step - loss: 0.0278
Epoch 407/800
30/30 [==============================] - 0s 173us/step - loss: 0.0283
Epoch 408/800
30/30 [==============================] - 0s 157us/step - loss: 0.0277
Epoch 409/800
30/30 [==============================] - 0s 175us/step - loss: 0.0281
Epoch 410/800
30/30 [==============================] - 0s 177us/step - loss: 0.0275
Epoch 411/800
30/30 [==============================] - 0s 188us/step - loss: 0.0273
Epoch 412/800
30/30 [==============================] - 0s 156us/step - loss: 0.0275
Epoch 413/800
30/30 [==============================] - 0s 184us/step - loss: 0.0266
Epoch 414/800
30/30 [==============================] - 0s 188us/step - loss: 0.0271
Epoch 415/800
30/30 [==============================] - 0s 168us/step - loss: 0.0273
Epoch 416/800
30/30 [==============================] - 0s 155us/step - loss: 0.0275
Epoch 417/800
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Epoch 418/800
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Epoch 419/800
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Epoch 420/800
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Epoch 421/800
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Epoch 422/800
30/30 [==============================] - 0s 156us/step - loss: 0.0266
Epoch 423/800
30/30 [==============================] - 0s 171us/step - loss: 0.0278
Epoch 424/800
30/30 [==============================] - 0s 155us/step - loss: 0.0294
Epoch 425/800
30/30 [==============================] - 0s 155us/step - loss: 0.0278
Epoch 426/800
30/30 [==============================] - 0s 168us/step - loss: 0.0283
Epoch 427/800
30/30 [==============================] - 0s 198us/step - loss: 0.0278
Epoch 428/800
30/30 [==============================] - 0s 165us/step - loss: 0.0273
Epoch 429/800
30/30 [==============================] - 0s 187us/step - loss: 0.0273
Epoch 430/800
30/30 [==============================] - 0s 214us/step - loss: 0.0270
Epoch 431/800
30/30 [==============================] - 0s 198us/step - loss: 0.0265
Epoch 432/800
30/30 [==============================] - 0s 180us/step - loss: 0.0265
Epoch 433/800
30/30 [==============================] - 0s 189us/step - loss: 0.0274
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Epoch 434/800
30/30 [==============================] - 0s 178us/step - loss: 0.0268
Epoch 435/800
30/30 [==============================] - 0s 193us/step - loss: 0.0273
Epoch 436/800
30/30 [==============================] - 0s 262us/step - loss: 0.0272
Epoch 437/800
30/30 [==============================] - 0s 216us/step - loss: 0.0290
Epoch 438/800
30/30 [==============================] - 0s 223us/step - loss: 0.0281
Epoch 439/800
30/30 [==============================] - 0s 167us/step - loss: 0.0281
Epoch 440/800
30/30 [==============================] - 0s 196us/step - loss: 0.0276
Epoch 441/800
30/30 [==============================] - 0s 168us/step - loss: 0.0270
Epoch 442/800
30/30 [==============================] - 0s 193us/step - loss: 0.0268
Epoch 443/800
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Epoch 444/800
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Epoch 445/800
30/30 [==============================] - 0s 176us/step - loss: 0.0267
Epoch 446/800
30/30 [==============================] - 0s 195us/step - loss: 0.0271
Epoch 447/800
30/30 [==============================] - 0s 140us/step - loss: 0.0268
Epoch 448/800
30/30 [==============================] - 0s 193us/step - loss: 0.0268
Epoch 449/800
30/30 [==============================] - 0s 171us/step - loss: 0.0271
Epoch 450/800
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Epoch 451/800
30/30 [==============================] - 0s 238us/step - loss: 0.0274
Epoch 452/800
30/30 [==============================] - 0s 183us/step - loss: 0.0270
Epoch 453/800
30/30 [==============================] - 0s 156us/step - loss: 0.0271
Epoch 454/800
30/30 [==============================] - 0s 203us/step - loss: 0.0284
Epoch 455/800
30/30 [==============================] - 0s 152us/step - loss: 0.0277
Epoch 456/800
30/30 [==============================] - 0s 171us/step - loss: 0.0279
Epoch 457/800
30/30 [==============================] - 0s 161us/step - loss: 0.0277
Epoch 458/800
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Epoch 459/800
30/30 [==============================] - 0s 170us/step - loss: 0.0272
Epoch 460/800
30/30 [==============================] - 0s 201us/step - loss: 0.0271
Epoch 461/800
30/30 [==============================] - 0s 169us/step - loss: 0.0268
Epoch 462/800
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30/30 [==============================] - 0s 166us/step - loss: 0.0267
Epoch 463/800
30/30 [==============================] - 0s 200us/step - loss: 0.0262
Epoch 464/800
30/30 [==============================] - 0s 206us/step - loss: 0.0269
Epoch 465/800
30/30 [==============================] - 0s 196us/step - loss: 0.0271
Epoch 466/800
30/30 [==============================] - 0s 231us/step - loss: 0.0280
Epoch 467/800
30/30 [==============================] - 0s 200us/step - loss: 0.0281
Epoch 468/800
30/30 [==============================] - 0s 233us/step - loss: 0.0275
Epoch 469/800
30/30 [==============================] - 0s 248us/step - loss: 0.0281
Epoch 470/800
30/30 [==============================] - 0s 239us/step - loss: 0.0274
Epoch 471/800
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Epoch 472/800
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Epoch 473/800
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Epoch 474/800
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Epoch 476/800
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Epoch 477/800
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Epoch 479/800
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Epoch 480/800
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Epoch 484/800
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Epoch 485/800
30/30 [==============================] - 0s 216us/step - loss: 0.0267
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30/30 [==============================] - 0s 487us/step - loss: 0.0268
Epoch 487/800
30/30 [==============================] - 0s 542us/step - loss: 0.0283
Epoch 488/800
30/30 [==============================] - 0s 338us/step - loss: 0.0291
Epoch 489/800
30/30 [==============================] - 0s 316us/step - loss: 0.0272
Epoch 490/800
30/30 [==============================] - 0s 280us/step - loss: 0.0273
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Epoch 491/800
30/30 [==============================] - 0s 320us/step - loss: 0.0270
Epoch 492/800
30/30 [==============================] - 0s 223us/step - loss: 0.0277
Epoch 493/800
30/30 [==============================] - 0s 396us/step - loss: 0.0282
Epoch 494/800
30/30 [==============================] - 0s 272us/step - loss: 0.0282
Epoch 495/800
30/30 [==============================] - 0s 341us/step - loss: 0.0274
Epoch 496/800
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Epoch 497/800
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Epoch 498/800
30/30 [==============================] - 0s 313us/step - loss: 0.0265
Epoch 499/800
30/30 [==============================] - 0s 291us/step - loss: 0.0264
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30/30 [==============================] - 0s 265us/step - loss: 0.0265
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Epoch 504/800
30/30 [==============================] - 0s 353us/step - loss: 0.0272
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Epoch 517/800
30/30 [==============================] - 0s 337us/step - loss: 0.0287
Epoch 518/800
30/30 [==============================] - 0s 155us/step - loss: 0.0273
Epoch 519/800
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30/30 [==============================] - 0s 189us/step - loss: 0.0278
Epoch 520/800
30/30 [==============================] - 0s 191us/step - loss: 0.0277
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Epoch 546/800
30/30 [==============================] - 0s 214us/step - loss: 0.0265
Epoch 547/800
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Epoch 548/800
30/30 [==============================] - 0s 223us/step - loss: 0.0269
Epoch 549/800
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Epoch 570/800
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Epoch 571/800
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Epoch 572/800
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Epoch 573/800
30/30 [==============================] - 0s 201us/step - loss: 0.0273
Epoch 574/800
30/30 [==============================] - 0s 222us/step - loss: 0.0267
Epoch 575/800
30/30 [==============================] - 0s 189us/step - loss: 0.0275
Epoch 576/800
```

```
30/30 [==============================] - 0s 196us/step - loss: 0.0268
Epoch 577/800
30/30 [==============================] - 0s 189us/step - loss: 0.0269
Epoch 578/800
30/30 [==============================] - 0s 184us/step - loss: 0.0265
Epoch 579/800
30/30 [==============================] - 0s 240us/step - loss: 0.0264
Epoch 580/800
30/30 [==============================] - 0s 167us/step - loss: 0.0263
Epoch 581/800
30/30 [==============================] - 0s 248us/step - loss: 0.0269
Epoch 582/800
30/30 [==============================] - 0s 224us/step - loss: 0.0273
Epoch 583/800
30/30 [==============================] - 0s 243us/step - loss: 0.0275
Epoch 584/800
30/30 [==============================] - 0s 210us/step - loss: 0.0284
Epoch 585/800
30/30 [==============================] - 0s 229us/step - loss: 0.0278
Epoch 586/800
30/30 [==============================] - 0s 289us/step - loss: 0.0272
Epoch 587/800
30/30 [==============================] - 0s 170us/step - loss: 0.0269
Epoch 588/800
30/30 [==============================] - 0s 362us/step - loss: 0.0270
Epoch 589/800
30/30 [==============================] - 0s 208us/step - loss: 0.0265
Epoch 590/800
30/30 [==============================] - 0s 303us/step - loss: 0.0265
Epoch 591/800
30/30 [==============================] - 0s 276us/step - loss: 0.0267
Epoch 592/800
30/30 [==============================] - 0s 294us/step - loss: 0.0271
Epoch 593/800
30/30 [==============================] - 0s 192us/step - loss: 0.0270
Epoch 594/800
30/30 [==============================] - 0s 177us/step - loss: 0.0272
Epoch 595/800
30/30 [==============================] - 0s 218us/step - loss: 0.0263
Epoch 596/800
30/30 [==============================] - 0s 270us/step - loss: 0.0276
Epoch 597/800
30/30 [==============================] - 0s 168us/step - loss: 0.0281
Epoch 598/800
30/30 [==============================] - 0s 214us/step - loss: 0.0278
Epoch 599/800
30/30 [==============================] - 0s 310us/step - loss: 0.0272
Epoch 600/800
30/30 [==============================] - 0s 195us/step - loss: 0.0280
Epoch 601/800
30/30 [==============================] - 0s 195us/step - loss: 0.0272
Epoch 602/800
30/30 [==============================] - 0s 181us/step - loss: 0.0267
Epoch 603/800
30/30 [==============================] - 0s 172us/step - loss: 0.0260
Epoch 604/800
30/30 [==============================] - 0s 179us/step - loss: 0.0264
```

```
Epoch 605/800
30/30 [==============================] - 0s 190us/step - loss: 0.0271
Epoch 606/800
30/30 [==============================] - 0s 177us/step - loss: 0.0270
Epoch 607/800
30/30 [==============================] - 0s 220us/step - loss: 0.0269
Epoch 608/800
30/30 [==============================] - 0s 213us/step - loss: 0.0272
Epoch 609/800
30/30 [==============================] - 0s 174us/step - loss: 0.0271
Epoch 610/800
30/30 [==============================] - 0s 185us/step - loss: 0.0269
Epoch 611/800
30/30 [==============================] - 0s 198us/step - loss: 0.0266
Epoch 612/800
30/30 [==============================] - 0s 197us/step - loss: 0.0266
Epoch 613/800
30/30 [==============================] - 0s 197us/step - loss: 0.0263
Epoch 614/800
30/30 [==============================] - 0s 189us/step - loss: 0.0270
Epoch 615/800
30/30 [==============================] - 0s 167us/step - loss: 0.0279
Epoch 616/800
30/30 [==============================] - 0s 155us/step - loss: 0.0288
Epoch 617/800
30/30 [==============================] - 0s 293us/step - loss: 0.0272
Epoch 618/800
30/30 [==============================] - 0s 293us/step - loss: 0.0271
Epoch 619/800
30/30 [==============================] - 0s 291us/step - loss: 0.0272
Epoch 620/800
30/30 [==============================] - 0s 273us/step - loss: 0.0266
Epoch 621/800
30/30 [==============================] - 0s 613us/step - loss: 0.0266
Epoch 622/800
30/30 [==============================] - 0s 306us/step - loss: 0.0261
Epoch 623/800
30/30 [==============================] - 0s 266us/step - loss: 0.0268
Epoch 624/800
30/30 [==============================] - 0s 442us/step - loss: 0.0266
Epoch 625/800
30/30 [==============================] - 0s 286us/step - loss: 0.0268
Epoch 626/800
30/30 [==============================] - 0s 295us/step - loss: 0.0275
Epoch 627/800
30/30 [==============================] - 0s 355us/step - loss: 0.0283
Epoch 628/800
30/30 [==============================] - 0s 291us/step - loss: 0.0278
Epoch 629/800
30/30 [==============================] - 0s 292us/step - loss: 0.0272
Epoch 630/800
30/30 [==============================] - 0s 298us/step - loss: 0.0279
Epoch 631/800
30/30 [==============================] - 0s 175us/step - loss: 0.0275
Epoch 632/800
30/30 [==============================] - 0s 274us/step - loss: 0.0267
Epoch 633/800
```

```
30/30 [==============================] - 0s 252us/step - loss: 0.0263
Epoch 634/800
30/30 [==============================] - 0s 210us/step - loss: 0.0264
Epoch 635/800
30/30 [==============================] - 0s 239us/step - loss: 0.0259
Epoch 636/800
30/30 [==============================] - 0s 203us/step - loss: 0.0263
Epoch 637/800
30/30 [==============================] - 0s 247us/step - loss: 0.0264
Epoch 638/800
30/30 [==============================] - 0s 267us/step - loss: 0.0268
Epoch 639/800
30/30 [==============================] - 0s 244us/step - loss: 0.0264
Epoch 640/800
30/30 [==============================] - 0s 291us/step - loss: 0.0268
Epoch 641/800
30/30 [==============================] - 0s 200us/step - loss: 0.0284
Epoch 642/800
30/30 [==============================] - 0s 218us/step - loss: 0.0285
Epoch 643/800
30/30 [==============================] - 0s 188us/step - loss: 0.0274
Epoch 644/800
30/30 [==============================] - 0s 231us/step - loss: 0.0276
Epoch 645/800
30/30 [==============================] - 0s 231us/step - loss: 0.0277
Epoch 646/800
30/30 [==============================] - 0s 225us/step - loss: 0.0271
Epoch 647/800
30/30 [==============================] - 0s 202us/step - loss: 0.0273
Epoch 648/800
30/30 [==============================] - 0s 359us/step - loss: 0.0271
Epoch 649/800
30/30 [==============================] - 0s 217us/step - loss: 0.0263
Epoch 650/800
30/30 [==============================] - 0s 251us/step - loss: 0.0264
Epoch 651/800
30/30 [==============================] - 0s 183us/step - loss: 0.0265
Epoch 652/800
30/30 [==============================] - 0s 246us/step - loss: 0.0273
Epoch 653/800
30/30 [==============================] - 0s 181us/step - loss: 0.0270
Epoch 654/800
30/30 [==============================] - 0s 149us/step - loss: 0.0276
Epoch 655/800
30/30 [==============================] - 0s 160us/step - loss: 0.0278
Epoch 656/800
30/30 [==============================] - 0s 146us/step - loss: 0.0274
Epoch 657/800
30/30 [==============================] - 0s 177us/step - loss: 0.0272
Epoch 658/800
30/30 [==============================] - 0s 153us/step - loss: 0.0270
Epoch 659/800
30/30 [==============================] - 0s 159us/step - loss: 0.0276
Epoch 660/800
30/30 [==============================] - 0s 221us/step - loss: 0.0272
Epoch 661/800
30/30 [==============================] - 0s 338us/step - loss: 0.0265
```

```
Epoch 662/800
30/30 [==============================] - 0s 181us/step - loss: 0.0265
Epoch 663/800
30/30 [==============================] - 0s 157us/step - loss: 0.0262
Epoch 664/800
30/30 [==============================] - 0s 268us/step - loss: 0.0262
Epoch 665/800
30/30 [==============================] - 0s 343us/step - loss: 0.0270
Epoch 666/800
30/30 [==============================] - 0s 321us/step - loss: 0.0268
Epoch 667/800
30/30 [==============================] - 0s 603us/step - loss: 0.0270
Epoch 668/800
30/30 [==============================] - 0s 321us/step - loss: 0.0269
Epoch 669/800
30/30 [==============================] - 0s 355us/step - loss: 0.0277
Epoch 670/800
30/30 [==============================] - 0s 344us/step - loss: 0.0270
Epoch 671/800
30/30 [==============================] - 0s 937us/step - loss: 0.0289
Epoch 672/800
30/30 [==============================] - 0s 557us/step - loss: 0.0279
Epoch 673/800
30/30 [==============================] - 0s 1ms/step - loss: 0.0266
Epoch 674/800
30/30 [==============================] - 0s 225us/step - loss: 0.0260
Epoch 675/800
30/30 [==============================] - 0s 149us/step - loss: 0.0263
Epoch 676/800
30/30 [==============================] - 0s 205us/step - loss: 0.0269
Epoch 677/800
30/30 [==============================] - 0s 190us/step - loss: 0.0266
Epoch 678/800
30/30 [==============================] - 0s 220us/step - loss: 0.0269
Epoch 679/800
30/30 [==============================] - 0s 212us/step - loss: 0.0275
Epoch 680/800
30/30 [==============================] - 0s 177us/step - loss: 0.0274
Epoch 681/800
30/30 [==============================] - 0s 210us/step - loss: 0.0274
Epoch 682/800
30/30 [==============================] - 0s 195us/step - loss: 0.0269
Epoch 683/800
30/30 [==============================] - 0s 169us/step - loss: 0.0269
Epoch 684/800
30/30 [==============================] - 0s 220us/step - loss: 0.0266
Epoch 685/800
30/30 [==============================] - 0s 200us/step - loss: 0.0266
Epoch 686/800
30/30 [==============================] - 0s 273us/step - loss: 0.0271
Epoch 687/800
30/30 [==============================] - 0s 180us/step - loss: 0.0264
Epoch 688/800
30/30 [==============================] - 0s 244us/step - loss: 0.0258
Epoch 689/800
30/30 [==============================] - 0s 202us/step - loss: 0.0261
Epoch 690/800
```

```
30/30 [==============================] - 0s 285us/step - loss: 0.0266
Epoch 691/800
30/30 [==============================] - 0s 159us/step - loss: 0.0272
Epoch 692/800
30/30 [==============================] - 0s 175us/step - loss: 0.0274
Epoch 693/800
30/30 [==============================] - 0s 280us/step - loss: 0.0284
Epoch 694/800
30/30 [==============================] - 0s 234us/step - loss: 0.0270
Epoch 695/800
30/30 [==============================] - 0s 227us/step - loss: 0.0269
Epoch 696/800
30/30 [==============================] - 0s 213us/step - loss: 0.0271
Epoch 697/800
30/30 [==============================] - 0s 314us/step - loss: 0.0266
Epoch 698/800
30/30 [==============================] - 0s 245us/step - loss: 0.0273
Epoch 699/800
30/30 [==============================] - 0s 283us/step - loss: 0.0279
Epoch 700/800
30/30 [==============================] - 0s 295us/step - loss: 0.0272
Epoch 701/800
30/30 [==============================] - 0s 179us/step - loss: 0.0268
Epoch 702/800
30/30 [==============================] - 0s 205us/step - loss: 0.0268
Epoch 703/800
30/30 [==============================] - 0s 203us/step - loss: 0.0269
Epoch 704/800
30/30 [==============================] - 0s 224us/step - loss: 0.0273
Epoch 705/800
30/30 [==============================] - 0s 196us/step - loss: 0.0271
Epoch 706/800
30/30 [==============================] - 0s 213us/step - loss: 0.0266
Epoch 707/800
30/30 [==============================] - 0s 219us/step - loss: 0.0264
Epoch 708/800
30/30 [==============================] - 0s 259us/step - loss: 0.0265
Epoch 709/800
30/30 [==============================] - 0s 210us/step - loss: 0.0268
Epoch 710/800
30/30 [==============================] - 0s 214us/step - loss: 0.0271
Epoch 711/800
30/30 [==============================] - 0s 223us/step - loss: 0.0272
Epoch 712/800
30/30 [==============================] - 0s 333us/step - loss: 0.0276
Epoch 713/800
30/30 [==============================] - 0s 265us/step - loss: 0.0267
Epoch 714/800
30/30 [==============================] - 0s 220us/step - loss: 0.0267
Epoch 715/800
30/30 [==============================] - 0s 250us/step - loss: 0.0266
Epoch 716/800
30/30 [==============================] - 0s 160us/step - loss: 0.0269
Epoch 717/800
30/30 [==============================] - 0s 256us/step - loss: 0.0268
Epoch 718/800
30/30 [==============================] - 0s 188us/step - loss: 0.0261
```

```
Epoch 719/800
30/30 [==============================] - 0s 275us/step - loss: 0.0259
Epoch 720/800
30/30 [==============================] - 0s 208us/step - loss: 0.0264
Epoch 721/800
30/30 [==============================] - 0s 274us/step - loss: 0.0261
Epoch 722/800
30/30 [==============================] - 0s 215us/step - loss: 0.0265
Epoch 723/800
30/30 [==============================] - 0s 268us/step - loss: 0.0262
Epoch 724/800
30/30 [==============================] - 0s 269us/step - loss: 0.0264
Epoch 725/800
30/30 [==============================] - 0s 189us/step - loss: 0.0262
Epoch 726/800
30/30 [==============================] - 0s 336us/step - loss: 0.0292
Epoch 727/800
30/30 [==============================] - 0s 300us/step - loss: 0.0276
Epoch 728/800
30/30 [==============================] - 0s 299us/step - loss: 0.0288
Epoch 729/800
30/30 [==============================] - 0s 325us/step - loss: 0.0269
Epoch 730/800
30/30 [==============================] - 0s 190us/step - loss: 0.0269
Epoch 731/800
30/30 [==============================] - 0s 319us/step - loss: 0.0278
Epoch 732/800
30/30 [==============================] - 0s 225us/step - loss: 0.0270
Epoch 733/800
30/30 [==============================] - 0s 264us/step - loss: 0.0276
Epoch 734/800
30/30 [==============================] - 0s 219us/step - loss: 0.0274
Epoch 735/800
30/30 [==============================] - 0s 209us/step - loss: 0.0271
Epoch 736/800
30/30 [==============================] - 0s 302us/step - loss: 0.0267
Epoch 737/800
30/30 [==============================] - 0s 284us/step - loss: 0.0267
Epoch 738/800
30/30 [==============================] - 0s 427us/step - loss: 0.0261
Epoch 739/800
30/30 [==============================] - 0s 569us/step - loss: 0.0263
Epoch 740/800
30/30 [==============================] - 0s 252us/step - loss: 0.0262
Epoch 741/800
30/30 [==============================] - 0s 234us/step - loss: 0.0265
Epoch 742/800
30/30 [==============================] - 0s 450us/step - loss: 0.0267
Epoch 743/800
30/30 [==============================] - 0s 486us/step - loss: 0.0275
Epoch 744/800
30/30 [==============================] - 0s 456us/step - loss: 0.0273
Epoch 745/800
30/30 [==============================] - 0s 194us/step - loss: 0.0275
Epoch 746/800
30/30 [==============================] - 0s 230us/step - loss: 0.0278
Epoch 747/800
```

```
30/30 [==============================] - 0s 244us/step - loss: 0.0267
Epoch 748/800
30/30 [==============================] - 0s 213us/step - loss: 0.0273
Epoch 749/800
30/30 [==============================] - 0s 210us/step - loss: 0.0274
Epoch 750/800
30/30 [==============================] - 0s 210us/step - loss: 0.0274
Epoch 751/800
30/30 [==============================] - 0s 188us/step - loss: 0.0268
Epoch 752/800
30/30 [==============================] - 0s 222us/step - loss: 0.0266
Epoch 753/800
30/30 [==============================] - 0s 227us/step - loss: 0.0265
Epoch 754/800
30/30 [==============================] - 0s 243us/step - loss: 0.0269
Epoch 755/800
30/30 [==============================] - 0s 474us/step - loss: 0.0273
Epoch 756/800
30/30 [==============================] - 0s 558us/step - loss: 0.0275
Epoch 757/800
30/30 [==============================] - 0s 356us/step - loss: 0.0271
Epoch 758/800
30/30 [==============================] - 0s 570us/step - loss: 0.0270
Epoch 759/800
30/30 [==============================] - 0s 349us/step - loss: 0.0269
Epoch 760/800
30/30 [==============================] - 0s 698us/step - loss: 0.0267
Epoch 761/800
30/30 [==============================] - 0s 361us/step - loss: 0.0264
Epoch 762/800
30/30 [==============================] - 0s 463us/step - loss: 0.0264
Epoch 763/800
30/30 [==============================] - 0s 664us/step - loss: 0.0265
Epoch 764/800
30/30 [==============================] - 0s 387us/step - loss: 0.0258
Epoch 765/800
30/30 [==============================] - 0s 188us/step - loss: 0.0260
Epoch 766/800
30/30 [==============================] - 0s 333us/step - loss: 0.0267
Epoch 767/800
30/30 [==============================] - 0s 394us/step - loss: 0.0261
Epoch 768/800
30/30 [==============================] - 0s 303us/step - loss: 0.0270
Restoring model weights from the end of the best epoch
Epoch 00768: early stopping
best epoch =  688
smallest loss = 0.025820961222052574
```

In [7]:

```
# Task 2.1 Part e
from sklearn import metrics

# This line of code can be used to reconstruct the saved model. The name of t
recon_model3 = keras.models.load_model("best_model3")

import matplotlib.pyplot as plt

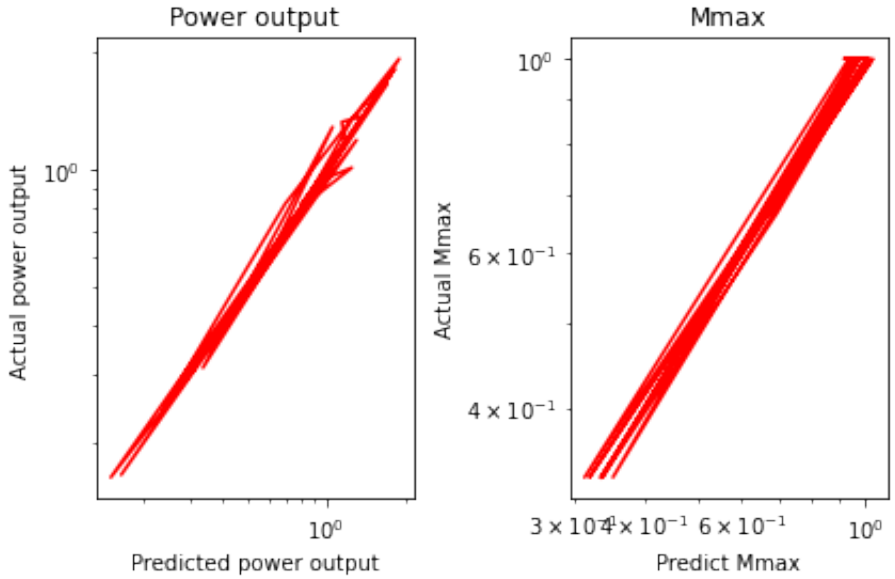
y_predictm = []
y_testm = []
Wdotpredm = []
Wdotorigm = []
Mmaxpredm = []
Mmaxorigm = []

for i in range(len(X_train2)):
    testm = [[X_train2[i][0], X_train2[i][1], X_train2[i][2]]]
    testarraym = np.array(testm)
    a3 = recon_model3.predict(testarraym)
    y_predictm.append([a3[0][0], a3[0][1], a3[0][2]])
    y_testm.append([y_train2[i][0], y_train2[i][1], y_train2[i][2]])
    Wdotpredm.append([a3[0][2]])
    Mmaxpredm.append([a3[0][0]])
    Wdotorigm.append([y_train2[i][2]])
    Mmaxorigm.append([y_train2[i][0]])

fig,(ax3, ax4) = plt.subplots(1, 2)
ax3.loglog(Wdotpredm, Wdotorigm, c='r')
ax3.set_xlabel('Predicted power output')
ax3.set_ylabel('Actual power output')
ax3.title.set_text('Power output');

ax4.loglog(Mmaxpredm, Mmaxorigm, c='r')
ax4.set_xlabel('Predict Mmax')
ax4.set_ylabel('Actual Mmax')
ax4.title.set_text('Mmax');
fig.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Mmax = metrics.mean_absolute_error(y_predictm[:][0],y_testm[:][0])
mae_Wdot = metrics.mean_absolute_error(y_predictm[:][2],y_testm[:][2])
mae_Vl = metrics.mean_absolute_error(y_predictm[:][1],y_testm[:][1])
print('mean absolute error between predictions and the collection of test dat
```




```
mean absolute error between predictions and the collection of test data: Vl =
0.021800673051404245  Wdot =  0.017343804523116606  Mmax =  0.0070730010357812
16
```

In [345…

```
# Task 2.1 Part f

# This line of code can be used to reconstruct the saved model. The name of t
recon_model3 = keras.models.load_model("best_model3")

import matplotlib.pyplot as plt

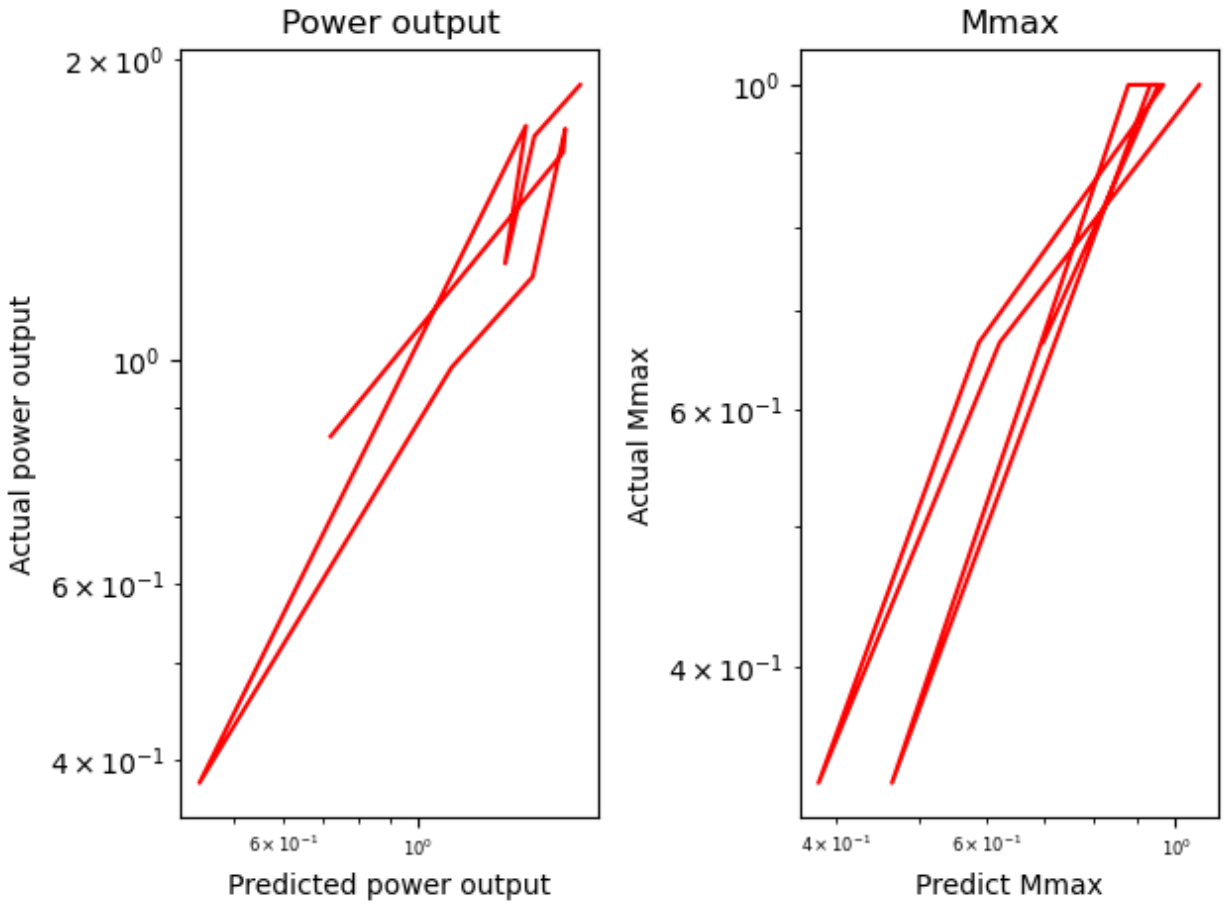
y_predictmn = []
y_trainmn = []
Wdotpredmn = []
Wdotorigmn = []
Mmaxpredmn = []
Mmaxorigmn = []

for i in range(len(X_test2)):
    testm = [[X_test2[i][0], X_test2[i][1], X_test2[i][2]]]
    testarraym = np.array(testm)
    a3 = recon_model3.predict(testarraym)
    y_predictmn.append([a3[0][0], a3[0][1], a3[0][2]])
    Wdotpredmn.append([a3[0][2]])
    Mmaxpredmn.append([a3[0][0]])
    Wdotorigmn.append([y_test2[i][2]])
    Mmaxorigmn.append([y_test2[i][0]])

fig,(ax3, ax4) = plt.subplots(1, 2)
ax3.loglog(Wdotpredmn, Wdotorigmn, c='r')
ax3.set_xlabel('Predicted power output')
ax3.set_ylabel('Actual power output')
ax3.title.set_text('Power output');

ax4.loglog(Mmaxpredmn, Mmaxorigmn, c='r')
ax4.set_xlabel('Predict Mmax')
ax4.set_ylabel('Actual Mmax')
ax4.title.set_text('Mmax');
fig.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Mmax = metrics.mean_absolute_error(y_predictmn[:][0],y_test2[:][0])
mae_Wdot = metrics.mean_absolute_error(y_predictmn[:][2],y_test2[:][2])
mae_Vl = metrics.mean_absolute_error(y_predictmn[:][1],y_test2[:][1])
print('mean absolute error between predictions and the collection of test dat
```




```
mean absolute error between predictions and the collection of test data: Vl =
0.07681843488357205  Wdot =  0.06591972105535963  Mmax =  0.038822428489870976
```

In [8]:

```
#Task 2.2 Part a
import math, numpy
#Part 2 input data: Mode number, Air temp (degC), ID (W/sqm), load resistance
# - split into training and validation sets, add some noise
xdata = [[1.0, 10.0, 200.0, 24.3],
 [2.0, 10.0, 200.0, 24.3],
 [3.0, 10.0, 200.0, 24.3],
 [1.0, 10.0, 200.0, 51.8],
 [2.0, 10.0, 200.0, 51.8],
 [3.0, 10.0, 200.0, 51.8],
 [1.0, 10.0, 200.0, 96.2],
 [2.0, 10.0, 200.0, 96.2],
 [3.0, 10.0, 200.0, 96.2],
 [1.0, 10.0, 200.0, 170.1],
 [2.0, 10.0, 200.0, 170.1],
 [3.0, 10.0, 200.0, 170.1],
 [1.0, 10.0, 500.0, 7.0],
 [2.0, 10.0, 500.0, 7.0],
 [3.0, 10.0, 500.0, 7.0],
 [1.0, 10.0, 500.0, 21.2],
 [2.0, 10.0, 500.0, 21.2],
```

```
 [3.0, 10.0, 500.0, 21.2],
 [1.0, 10.0, 500.0, 43.2],
 [2.0, 10.0, 500.0, 43.2],
 [3.0, 10.0, 500.0, 43.2],
 [1.0, 10.0, 500.0, 79.1],
 [2.0, 10.0, 500.0, 79.1],
 [3.0, 10.0, 500.0, 79.1],
 [1.0, 10.0, 700.0, 4.9],
 [2.0, 10.0, 700.0, 4.9],
 [3.0, 10.0, 700.0, 4.9],
 [1.0, 10.0, 700.0, 14.3],
 [2.0, 10.0, 700.0, 14.3],
 [3.0, 10.0, 700.0, 14.3],
 [1.0, 10.0, 700.0, 29.7],
 [2.0, 10.0, 700.0, 29.7],
 [3.0, 10.0, 700.0, 29.7],
 [1.0, 10.0, 700.0, 55.3],
 [2.0, 10.0, 700.0, 55.3],
 [3.0, 10.0, 700.0, 55.3],
 [1.0, 10.0, 1000.0, 3.92],
 [2.0, 10.0, 1000.0, 3.92],
 [3.0, 10.0, 1000.0, 3.92],
 [1.0, 10.0, 1000.0, 11.7],
 [2.0, 10.0, 1000.0, 11.7],
 [3.0, 10.0, 1000.0, 11.7],
 [1.0, 10.0, 1000.0, 25.2],
 [2.0, 10.0, 1000.0, 25.2],
 [3.0, 10.0, 1000.0, 25.2],
 [1.0, 10.0, 1000.0, 41.6],
 [2.0, 10.0, 1000.0, 41.6],
 [3.0, 10.0, 1000.0, 41.6]]

#Part 1 output data for above specified Mode and conditons: VL (V) and Power
ydata = [[46.0, 87.3],
         [27.9, 64.2],
         [27.9, 32.1],
         [46.0, 40.9],
         [92.1, 163.9],
         [59.5, 68.5],
         [46.0, 22.0],
         [92.1, 88.2],
         [110.6, 127.2],
         [46.0, 12.4],
         [92.1, 49.9],
         [184.2, 199.6],
         [48.4, 335.3],
         [20.8, 124.3],
         [20.8, 62.1],
         [48.4, 110.7],
         [96.8, 442.9],
         [63.1, 188.2],
         [48.4, 54.3],
         [96.9, 217.3],
```

```
          [128.7, 383.6],
          [48.4, 29.6],
          [96.8, 118.7],
          [193.7, 474.8],
          [49.3, 496.1],
          [20.4, 171.2],
          [20.4, 85.6],
          [49.3, 169.9],
          [98.6, 679.9],
          [59.7, 249.8],
          [49.3, 81.8],
          [98.6, 327.4],
          [124.1, 518.9],
          [49.305, 43.9],
          [98.6, 175.8],
          [197.2, 703.3],
          [50.8, 658.9],
          [23.1, 272.9],
          [23.1, 136.4],
          [50.8, 220.7],
          [101.6, 883.1],
          [69.0, 407.2],
          [50.8, 102.5],
          [101.6, 410.0],
          [148.6, 877.2],
          [50.8, 62.0],
          [101.6, 248.3],
          [203.2, 993.5]]

xarray= numpy.array(xdata)
yarray= numpy.array(ydata)

Mp = []
Vlp = []
Wdotp = []
Tairp =[]
Idp =[]
Rlp =[]

for x in range(len(xarray)):
    Mp.append(xarray[x][0])
    Tairp.append(xarray[x][1])
    Idp.append(xarray[x][2])
    Rlp.append(xarray[x][3])

for y in range(len(yarray)):
    Vlp.append(yarray[y][0])
    Wdotp.append(yarray[y][1])

medTairp = median(Tairp)
medIdp = median(Idp)
medRlp = median(Rlp)
medVlp = median(Vlp)
```

```
medWdotp = median(Wdotp)
medMp = median(Mp)

Tairpn = Tairp/medTairp
Idpn = Idp/medIdp
Rlpn = Rlp/medRlp
Vlpn = Vlp/medVlp
Wdotpn = Wdotp/medWdotp
Mpn = Mp/medMp

xarraypn = np.column_stack((Mpn, Tairpn, Idpn, Rlpn))
yarraypn = np.column_stack((Vlpn, Wdotpn))

print(xarraypn)
print(yarraypn)
```

```
[[0.5        1.         0.33333333 0.8852459 ]
 [1.         1.         0.33333333 0.8852459 ]
 [1.5        1.         0.33333333 0.8852459 ]
 [0.5        1.         0.33333333 1.8870674 ]
 [1.         1.         0.33333333 1.8870674 ]
 [1.5        1.         0.33333333 1.8870674 ]
 [0.5        1.         0.33333333 3.50455373]
 [1.         1.         0.33333333 3.50455373]
 [1.5        1.         0.33333333 3.50455373]
 [0.5        1.         0.33333333 6.19672131]
 [1.         1.         0.33333333 6.19672131]
 [1.5        1.         0.33333333 6.19672131]
 [0.5        1.         0.83333333 0.25500911]
 [1.         1.         0.83333333 0.25500911]
 [1.5        1.         0.83333333 0.25500911]
 [0.5        1.         0.83333333 0.7723133 ]
 [1.         1.         0.83333333 0.7723133 ]
 [1.5        1.         0.83333333 0.7723133 ]
 [0.5        1.         0.83333333 1.57377049]
 [1.         1.         0.83333333 1.57377049]
 [1.5        1.         0.83333333 1.57377049]
 [0.5        1.         0.83333333 2.88160291]
 [1.         1.         0.83333333 2.88160291]
 [1.5        1.         0.83333333 2.88160291]
 [0.5        1.         1.16666667 0.17850638]
 [1.         1.         1.16666667 0.17850638]
 [1.5        1.         1.16666667 0.17850638]
 [0.5        1.         1.16666667 0.52094718]
 [1.         1.         1.16666667 0.52094718]
 [1.5        1.         1.16666667 0.52094718]
 [0.5        1.         1.16666667 1.08196721]
 [1.         1.         1.16666667 1.08196721]
 [1.5        1.         1.16666667 1.08196721]
 [0.5        1.         1.16666667 2.01457195]
 [1.         1.         1.16666667 2.01457195]
 [1.5        1.         1.16666667 2.01457195]
 [0.5        1.         1.66666667 0.1428051 ]
 [1.         1.         1.66666667 0.1428051 ]
 [1.5        1.         1.66666667 0.1428051 ]
```

```
 [0.5        1.         1.66666667 0.42622951]
 [1.         1.         1.66666667 0.42622951]
 [1.5        1.         1.66666667 0.42622951]
 [0.5        1.         1.66666667 0.91803279]
 [1.         1.         1.66666667 0.91803279]
 [1.5        1.         1.66666667 0.91803279]
 [0.5        1.         1.66666667 1.5154827 ]
 [1.         1.         1.66666667 1.5154827 ]
 [1.5        1.         1.66666667 1.5154827 ]]
[[0.83408885 0.51187335]
 [0.50589302 0.3764292 ]
 [0.50589302 0.1882146 ]
 [0.83408885 0.23981237]
 [1.66999093 0.9610085 ]
 [1.07887579 0.40164175]
 [0.83408885 0.12899443]
 [1.66999093 0.5171504 ]
 [2.00543971 0.74582234]
 [0.83408885 0.07270595]
 [1.66999093 0.29258282]
 [3.33998187 1.17033128]
 [0.87760653 1.96599238]
 [0.37715322 0.72881853]
 [0.37715322 0.36411609]
 [0.87760653 0.64907652]
 [1.75521306 2.59689241]
 [1.14415231 1.10348871]
 [0.87760653 0.31838171]
 [1.75702629 1.27411316]
 [2.33363554 2.24919378]
 [0.87760653 0.17355614]
 [1.75521306 0.69598358]
 [3.51223935 2.78393433]
 [0.89392566 2.90882439]
 [0.36990027 1.0038112 ]
 [0.36990027 0.5019056 ]
 [0.89392566 0.9961888 ]
 [1.78785131 3.98651422]
 [1.08250227 1.46467312]
 [0.89392566 0.47962474]
 [1.78785131 1.91967165]
 [2.25022665 3.04250953]
 [0.89401632 0.25740252]
 [1.78785131 1.03078276]
 [3.57570263 4.12371738]
 [0.92112421 3.86338317]
 [0.41885766 1.60011727]
 [0.41885766 0.79976546]
 [0.92112421 1.29404867]
 [1.84224841 5.17795368]
 [1.25113327 2.38756963]
 [0.92112421 0.60099678]
 [1.84224841 2.4039871 ]
 [2.69446963 5.14335972]
 [0.92112421 0.36352976]
 [1.84224841 1.45587804]
 [3.68449683 5.82527118]]
```

In [9]:

```
#Task 2.2 Part b
from sklearn.model_selection import train_test_split

X_train3, X_test3, y_train3, y_test3 = train_test_split(xarraypn, yarraypn, t

print(X_train3)
print(y_train3)
print(X_test3)
print(y_test3)
```

```
[[0.5        1.         0.33333333 3.50455373]
 [0.5        1.         1.66666667 0.42622951]
 [0.5        1.         1.16666667 2.01457195]
 [1.         1.         0.83333333 0.25500911]
 [1.5        1.         0.83333333 0.7723133 ]
 [0.5        1.         1.66666667 1.5154827 ]
 [0.5        1.         0.83333333 0.7723133 ]
 [0.5        1.         0.33333333 6.19672131]
 [1.         1.         0.83333333 0.7723133 ]
 [1.5        1.         1.16666667 0.52094718]
 [1.5        1.         1.16666667 1.08196721]
 [1.         1.         1.66666667 1.5154827 ]
 [0.5        1.         0.33333333 0.8852459 ]
 [1.         1.         1.16666667 1.08196721]
 [0.5        1.         1.16666667 1.08196721]
 [1.5        1.         0.33333333 1.8870674 ]
 [1.5        1.         0.33333333 6.19672131]
 [1.         1.         1.16666667 2.01457195]
 [1.         1.         0.33333333 0.8852459 ]
 [1.5        1.         1.66666667 0.91803279]
 [0.5        1.         0.83333333 2.88160291]
 [1.5        1.         0.33333333 0.8852459 ]
 [0.5        1.         1.66666667 0.1428051 ]
 [1.5        1.         1.16666667 2.01457195]
 [1.5        1.         0.83333333 2.88160291]
 [1.5        1.         1.66666667 0.42622951]
 [1.         1.         0.33333333 6.19672131]
 [1.         1.         0.83333333 2.88160291]
 [0.5        1.         0.83333333 1.57377049]
 [1.5        1.         1.66666667 1.5154827 ]
 [1.5        1.         0.83333333 1.57377049]
 [1.         1.         0.33333333 3.50455373]
 [0.5        1.         1.66666667 0.91803279]
 [1.5        1.         0.83333333 0.25500911]
 [1.         1.         1.16666667 0.52094718]
 [1.5        1.         1.66666667 0.1428051 ]]
[[0.83408885 0.12899443]
 [0.92112421 1.29404867]
 [0.89401632 0.25740252]
 [0.37715322 0.72881853]
 [1.14415231 1.10348871]
 [0.92112421 0.36352976]
 [0.87760653 0.64907652]
 [0.83408885 0.07270595]
```

```
 [1.75521306 2.59689241]
 [1.08250227 1.46467312]
 [2.25022665 3.04250953]
 [1.84224841 1.45587804]
 [0.83408885 0.51187335]
 [1.78785131 1.91967165]
 [0.89392566 0.47962474]
 [1.07887579 0.40164175]
 [3.33998187 1.17033128]
 [1.78785131 1.03078276]
 [0.50589302 0.3764292 ]
 [2.69446963 5.14335972]
 [0.87760653 0.17355614]
 [0.50589302 0.1882146 ]
 [0.92112421 3.86338317]
 [3.57570263 4.12371738]
 [3.51223935 2.78393433]
 [1.25113327 2.38756963]
 [1.66999093 0.29258282]
 [1.75521306 0.69598358]
 [0.87760653 0.31838171]
 [3.68449683 5.82527118]
 [2.33363554 2.24919378]
 [1.66999093 0.5171504 ]
 [0.92112421 0.60099678]
 [0.37715322 0.36411609]
 [1.78785131 3.98651422]
 [0.41885766 0.79976546]]
[[0.5        1.         1.16666667 0.52094718]
 [1.         1.         1.66666667 0.42622951]
 [1.5        1.         1.16666667 0.17850638]
 [1.         1.         1.66666667 0.91803279]
 [0.5        1.         1.16666667 0.17850638]
 [1.         1.         1.66666667 0.1428051 ]
 [0.5        1.         0.83333333 0.25500911]
 [1.         1.         0.83333333 1.57377049]
 [1.         1.         0.33333333 1.8870674 ]
 [1.         1.         1.16666667 0.17850638]
 [1.5        1.         0.33333333 3.50455373]
 [0.5        1.         0.33333333 1.8870674 ]]
[[0.89392566 0.9961888 ]
 [1.84224841 5.17795368]
 [0.36990027 0.5019056 ]
 [1.84224841 2.4039871 ]
 [0.89392566 2.90882439]
 [0.41885766 1.60011727]
 [0.87760653 1.96599238]
 [1.75702629 1.27411316]
 [1.66999093 0.9610085 ]
 [0.36990027 1.0038112 ]
 [2.00543971 0.74582234]
 [0.83408885 0.23981237]]
```

In [293…

```
# define neural network model

from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

modelv4 = keras.Sequential([
    keras.layers.Dense(16, activation=K.elu, input_shape=[4],  kernel_initial
    keras.layers.Dense(32, activation=K.elu,  kernel_initializer=initializer)
    keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(16,  activation=K.elu, kernel_initializer=initializer)
    keras.layers.Dense(2, kernel_initializer=initializer)
  ])
```

In [306…

```
#from tf.keras import optimizers
rms = keras.optimizers.RMSprop(0.0001)
modelv4.compile(loss='mean_absolute_error',optimizer=rms)
```

In [307…

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 80,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model4.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = modelv4.fit(X_train3,y_train3,epochs=800,callbacks=[es])

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))

modelv4.save('./best_model4')
```

```
Epoch 1/800
36/36 [==============================] - 1s 37ms/step - loss: 0.0378
Epoch 2/800
36/36 [==============================] - 0s 375us/step - loss: 0.0293
Epoch 3/800
36/36 [==============================] - 0s 360us/step - loss: 0.0329
Epoch 4/800
36/36 [==============================] - 0s 545us/step - loss: 0.0312
Epoch 5/800
36/36 [==============================] - 0s 469us/step - loss: 0.0297
Epoch 6/800
```

```
36/36 [==============================] - 0s 536us/step - loss: 0.0317
Epoch 7/800
36/36 [==============================] - 0s 847us/step - loss: 0.0276
Epoch 8/800
36/36 [==============================] - 0s 521us/step - loss: 0.0301
Epoch 9/800
36/36 [==============================] - 0s 486us/step - loss: 0.0282
Epoch 10/800
36/36 [==============================] - 0s 632us/step - loss: 0.0287
Epoch 11/800
36/36 [==============================] - 0s 363us/step - loss: 0.0279
Epoch 12/800
36/36 [==============================] - 0s 303us/step - loss: 0.0271
Epoch 13/800
36/36 [==============================] - 0s 286us/step - loss: 0.0290
Epoch 14/800
36/36 [==============================] - 0s 521us/step - loss: 0.0294
Epoch 15/800
36/36 [==============================] - 0s 641us/step - loss: 0.0304
Epoch 16/800
36/36 [==============================] - 0s 441us/step - loss: 0.0291
Epoch 17/800
36/36 [==============================] - 0s 479us/step - loss: 0.0270
Epoch 18/800
36/36 [==============================] - 0s 656us/step - loss: 0.0320
Epoch 19/800
36/36 [==============================] - 0s 629us/step - loss: 0.0312
Epoch 20/800
36/36 [==============================] - 0s 609us/step - loss: 0.0294
Epoch 21/800
36/36 [==============================] - 0s 339us/step - loss: 0.0290
Epoch 22/800
36/36 [==============================] - 0s 563us/step - loss: 0.0313
Epoch 23/800
36/36 [==============================] - 0s 420us/step - loss: 0.0266
Epoch 24/800
36/36 [==============================] - 0s 364us/step - loss: 0.0290
Epoch 25/800
36/36 [==============================] - 0s 423us/step - loss: 0.0274
Epoch 26/800
36/36 [==============================] - 0s 375us/step - loss: 0.0275
Epoch 27/800
36/36 [==============================] - 0s 388us/step - loss: 0.0283
Epoch 28/800
36/36 [==============================] - 0s 540us/step - loss: 0.0312
Epoch 29/800
36/36 [==============================] - 0s 325us/step - loss: 0.0288
Epoch 30/800
36/36 [==============================] - 0s 352us/step - loss: 0.0309
Epoch 31/800
36/36 [==============================] - 0s 352us/step - loss: 0.0270
Epoch 32/800
36/36 [==============================] - 0s 344us/step - loss: 0.0274
Epoch 33/800
36/36 [==============================] - 0s 274us/step - loss: 0.0299
Epoch 34/800
36/36 [==============================] - 0s 302us/step - loss: 0.0286
```

```
Epoch 35/800
36/36 [==============================] - 0s 275us/step - loss: 0.0281
Epoch 36/800
36/36 [==============================] - 0s 303us/step - loss: 0.0338
Epoch 37/800
36/36 [==============================] - 0s 349us/step - loss: 0.0285
Epoch 38/800
36/36 [==============================] - 0s 328us/step - loss: 0.0279
Epoch 39/800
36/36 [==============================] - 0s 384us/step - loss: 0.0269
Epoch 40/800
36/36 [==============================] - 0s 530us/step - loss: 0.0271
Epoch 41/800
36/36 [==============================] - 0s 337us/step - loss: 0.0282
Epoch 42/800
36/36 [==============================] - 0s 511us/step - loss: 0.0273
Epoch 43/800
36/36 [==============================] - 0s 408us/step - loss: 0.0268
Epoch 44/800
36/36 [==============================] - 0s 399us/step - loss: 0.0294
Epoch 45/800
36/36 [==============================] - 0s 467us/step - loss: 0.0283
Epoch 46/800
36/36 [==============================] - 0s 980us/step - loss: 0.0315
Epoch 47/800
36/36 [==============================] - 0s 562us/step - loss: 0.0304
Epoch 48/800
36/36 [==============================] - 0s 502us/step - loss: 0.0293
Epoch 49/800
36/36 [==============================] - 0s 729us/step - loss: 0.0271
Epoch 50/800
36/36 [==============================] - 0s 717us/step - loss: 0.0294
Epoch 51/800
36/36 [==============================] - 0s 506us/step - loss: 0.0309
Epoch 52/800
36/36 [==============================] - 0s 800us/step - loss: 0.0273
Epoch 53/800
36/36 [==============================] - 0s 762us/step - loss: 0.0269
Epoch 54/800
36/36 [==============================] - 0s 705us/step - loss: 0.0308
Epoch 55/800
36/36 [==============================] - 0s 476us/step - loss: 0.0283
Epoch 56/800
36/36 [==============================] - 0s 583us/step - loss: 0.0307
Epoch 57/800
36/36 [==============================] - 0s 334us/step - loss: 0.0303
Epoch 58/800
36/36 [==============================] - 0s 391us/step - loss: 0.0266
Epoch 59/800
36/36 [==============================] - 0s 333us/step - loss: 0.0288
Epoch 60/800
36/36 [==============================] - 0s 466us/step - loss: 0.0294
Epoch 61/800
36/36 [==============================] - 0s 739us/step - loss: 0.0272
Epoch 62/800
36/36 [==============================] - 0s 299us/step - loss: 0.0273
Epoch 63/800
```

```
36/36 [==============================] - 0s 280us/step - loss: 0.0275
Epoch 64/800
36/36 [==============================] - 0s 302us/step - loss: 0.0268
Epoch 65/800
36/36 [==============================] - 0s 367us/step - loss: 0.0263
Epoch 66/800
36/36 [==============================] - 0s 445us/step - loss: 0.0291
Epoch 67/800
36/36 [==============================] - 0s 315us/step - loss: 0.0266
Epoch 68/800
36/36 [==============================] - 0s 379us/step - loss: 0.0297
Epoch 69/800
36/36 [==============================] - 0s 388us/step - loss: 0.0294
Epoch 70/800
36/36 [==============================] - 0s 341us/step - loss: 0.0288
Epoch 71/800
36/36 [==============================] - 0s 353us/step - loss: 0.0292
Epoch 72/800
36/36 [==============================] - 0s 351us/step - loss: 0.0305
Epoch 73/800
36/36 [==============================] - 0s 404us/step - loss: 0.0278
Epoch 74/800
36/36 [==============================] - 0s 353us/step - loss: 0.0283
Epoch 75/800
36/36 [==============================] - 0s 327us/step - loss: 0.0268
Epoch 76/800
36/36 [==============================] - 0s 339us/step - loss: 0.0263
Epoch 77/800
36/36 [==============================] - 0s 411us/step - loss: 0.0276
Epoch 78/800
36/36 [==============================] - 0s 383us/step - loss: 0.0278
Epoch 79/800
36/36 [==============================] - 0s 363us/step - loss: 0.0260
Epoch 80/800
36/36 [==============================] - 0s 303us/step - loss: 0.0319
Epoch 81/800
36/36 [==============================] - 0s 306us/step - loss: 0.0284
Epoch 82/800
36/36 [==============================] - 0s 291us/step - loss: 0.0263
Epoch 83/800
36/36 [==============================] - 0s 289us/step - loss: 0.0275
Epoch 84/800
36/36 [==============================] - 0s 262us/step - loss: 0.0275
Epoch 85/800
36/36 [==============================] - 0s 279us/step - loss: 0.0310
Epoch 86/800
36/36 [==============================] - 0s 301us/step - loss: 0.0258
Epoch 87/800
36/36 [==============================] - 0s 289us/step - loss: 0.0274
Epoch 88/800
36/36 [==============================] - 0s 294us/step - loss: 0.0320
Epoch 89/800
36/36 [==============================] - 0s 295us/step - loss: 0.0264
Epoch 90/800
36/36 [==============================] - 0s 547us/step - loss: 0.0266
Epoch 91/800
36/36 [==============================] - 0s 287us/step - loss: 0.0265
```

```
Epoch 92/800
36/36 [==============================] - 0s 306us/step - loss: 0.0273
Epoch 93/800
36/36 [==============================] - 0s 312us/step - loss: 0.0292
Epoch 94/800
36/36 [==============================] - 0s 302us/step - loss: 0.0286
Epoch 95/800
36/36 [==============================] - 0s 289us/step - loss: 0.0294
Epoch 96/800
36/36 [==============================] - 0s 303us/step - loss: 0.0278
Epoch 97/800
36/36 [==============================] - 0s 433us/step - loss: 0.0293
Epoch 98/800
36/36 [==============================] - 0s 470us/step - loss: 0.0297
Epoch 99/800
36/36 [==============================] - 0s 329us/step - loss: 0.0276
Epoch 100/800
36/36 [==============================] - 0s 332us/step - loss: 0.0281
Epoch 101/800
36/36 [==============================] - 0s 325us/step - loss: 0.0263
Epoch 102/800
36/36 [==============================] - 0s 300us/step - loss: 0.0328
Epoch 103/800
36/36 [==============================] - 0s 341us/step - loss: 0.0273
Epoch 104/800
36/36 [==============================] - 0s 353us/step - loss: 0.0304
Epoch 105/800
36/36 [==============================] - 0s 297us/step - loss: 0.0270
Epoch 106/800
36/36 [==============================] - 0s 376us/step - loss: 0.0261
Epoch 107/800
36/36 [==============================] - 0s 330us/step - loss: 0.0285
Epoch 108/800
36/36 [==============================] - 0s 331us/step - loss: 0.0277
Epoch 109/800
36/36 [==============================] - 0s 368us/step - loss: 0.0281
Epoch 110/800
36/36 [==============================] - 0s 406us/step - loss: 0.0274
Epoch 111/800
36/36 [==============================] - 0s 330us/step - loss: 0.0272
Epoch 112/800
36/36 [==============================] - 0s 284us/step - loss: 0.0298
Epoch 113/800
36/36 [==============================] - 0s 394us/step - loss: 0.0276
Epoch 114/800
36/36 [==============================] - 0s 350us/step - loss: 0.0256
Epoch 115/800
36/36 [==============================] - 0s 416us/step - loss: 0.0288
Epoch 116/800
36/36 [==============================] - 0s 344us/step - loss: 0.0282
Epoch 117/800
36/36 [==============================] - 0s 494us/step - loss: 0.0262
Epoch 118/800
36/36 [==============================] - 0s 471us/step - loss: 0.0284
Epoch 119/800
36/36 [==============================] - 0s 417us/step - loss: 0.0262
Epoch 120/800
```

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36/36 [==============================] - 0s 452us/step - loss: 0.0284
Epoch 121/800
36/36 [==============================] - 0s 817us/step - loss: 0.0265
Epoch 122/800
36/36 [==============================] - 0s 574us/step - loss: 0.0278
Epoch 123/800
36/36 [==============================] - 0s 695us/step - loss: 0.0273
Epoch 124/800
36/36 [==============================] - 0s 597us/step - loss: 0.0256
Epoch 125/800
36/36 [==============================] - 0s 548us/step - loss: 0.0276
Epoch 126/800
36/36 [==============================] - 0s 649us/step - loss: 0.0289
Epoch 127/800
36/36 [==============================] - 0s 338us/step - loss: 0.0338
Epoch 128/800
36/36 [==============================] - 0s 451us/step - loss: 0.0263
Epoch 129/800
36/36 [==============================] - 0s 457us/step - loss: 0.0284
Epoch 130/800
36/36 [==============================] - 0s 414us/step - loss: 0.0267
Epoch 131/800
36/36 [==============================] - 0s 276us/step - loss: 0.0292
Epoch 132/800
36/36 [==============================] - 0s 325us/step - loss: 0.0269
Epoch 133/800
36/36 [==============================] - 0s 356us/step - loss: 0.0257
Epoch 134/800
36/36 [==============================] - 0s 324us/step - loss: 0.0270
Epoch 135/800
36/36 [==============================] - 0s 317us/step - loss: 0.0278
Epoch 136/800
36/36 [==============================] - 0s 313us/step - loss: 0.0260
Epoch 137/800
36/36 [==============================] - 0s 283us/step - loss: 0.0273
Epoch 138/800
36/36 [==============================] - 0s 279us/step - loss: 0.0292
Epoch 139/800
36/36 [==============================] - 0s 469us/step - loss: 0.0272
Epoch 140/800
36/36 [==============================] - 0s 691us/step - loss: 0.0290
Epoch 141/800
36/36 [==============================] - 0s 634us/step - loss: 0.0261
Epoch 142/800
36/36 [==============================] - 0s 600us/step - loss: 0.0276
Epoch 143/800
36/36 [==============================] - 0s 521us/step - loss: 0.0268
Epoch 144/800
36/36 [==============================] - 0s 509us/step - loss: 0.0271
Epoch 145/800
36/36 [==============================] - 0s 591us/step - loss: 0.0282
Epoch 146/800
36/36 [==============================] - 0s 644us/step - loss: 0.0273
Epoch 147/800
36/36 [==============================] - 0s 538us/step - loss: 0.0274
Epoch 148/800
36/36 [==============================] - 0s 548us/step - loss: 0.0257
```

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Epoch 149/800
36/36 [==============================] - 0s 701us/step - loss: 0.0271
Epoch 150/800
36/36 [==============================] - 0s 589us/step - loss: 0.0285
Epoch 151/800
36/36 [==============================] - 0s 504us/step - loss: 0.0301
Epoch 152/800
36/36 [==============================] - 0s 485us/step - loss: 0.0249
Epoch 153/800
36/36 [==============================] - 0s 546us/step - loss: 0.0268
Epoch 154/800
36/36 [==============================] - 0s 749us/step - loss: 0.0263
Epoch 155/800
36/36 [==============================] - 0s 541us/step - loss: 0.0284
Epoch 156/800
36/36 [==============================] - 0s 561us/step - loss: 0.0277
Epoch 157/800
36/36 [==============================] - 0s 301us/step - loss: 0.0301
Epoch 158/800
36/36 [==============================] - 0s 345us/step - loss: 0.0264
Epoch 159/800
36/36 [==============================] - 0s 457us/step - loss: 0.0258
Epoch 160/800
36/36 [==============================] - 0s 317us/step - loss: 0.0278
Epoch 161/800
36/36 [==============================] - 0s 279us/step - loss: 0.0298
Epoch 162/800
36/36 [==============================] - 0s 304us/step - loss: 0.0261
Epoch 163/800
36/36 [==============================] - 0s 339us/step - loss: 0.0306
Epoch 164/800
36/36 [==============================] - 0s 410us/step - loss: 0.0271
Epoch 165/800
36/36 [==============================] - 0s 468us/step - loss: 0.0290
Epoch 166/800
36/36 [==============================] - 0s 411us/step - loss: 0.0256
Epoch 167/800
36/36 [==============================] - 0s 484us/step - loss: 0.0258
Epoch 168/800
36/36 [==============================] - 0s 312us/step - loss: 0.0303
Epoch 169/800
36/36 [==============================] - 0s 328us/step - loss: 0.0259
Epoch 170/800
36/36 [==============================] - 0s 416us/step - loss: 0.0271
Epoch 171/800
36/36 [==============================] - 0s 364us/step - loss: 0.0283
Epoch 172/800
36/36 [==============================] - 0s 359us/step - loss: 0.0293
Epoch 173/800
36/36 [==============================] - 0s 330us/step - loss: 0.0283
Epoch 174/800
36/36 [==============================] - 0s 327us/step - loss: 0.0286
Epoch 175/800
36/36 [==============================] - 0s 301us/step - loss: 0.0281
Epoch 176/800
36/36 [==============================] - 0s 285us/step - loss: 0.0269
Epoch 177/800
```

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36/36 [==============================] - 0s 295us/step - loss: 0.0271
Epoch 178/800
36/36 [==============================] - 0s 270us/step - loss: 0.0287
Epoch 179/800
36/36 [==============================] - 0s 320us/step - loss: 0.0272
Epoch 180/800
36/36 [==============================] - 0s 320us/step - loss: 0.0288
Epoch 181/800
36/36 [==============================] - 0s 509us/step - loss: 0.0270
Epoch 182/800
36/36 [==============================] - 0s 327us/step - loss: 0.0297
Epoch 183/800
36/36 [==============================] - 0s 378us/step - loss: 0.0249
Epoch 184/800
36/36 [==============================] - 0s 433us/step - loss: 0.0295
Epoch 185/800
36/36 [==============================] - 0s 416us/step - loss: 0.0321
Epoch 186/800
36/36 [==============================] - 0s 395us/step - loss: 0.0254
Epoch 187/800
36/36 [==============================] - 0s 518us/step - loss: 0.0279
Epoch 188/800
36/36 [==============================] - 0s 331us/step - loss: 0.0305
Epoch 189/800
36/36 [==============================] - 0s 316us/step - loss: 0.0274
Epoch 190/800
36/36 [==============================] - 0s 421us/step - loss: 0.0287
Epoch 191/800
36/36 [==============================] - 0s 385us/step - loss: 0.0257
Epoch 192/800
36/36 [==============================] - 0s 397us/step - loss: 0.0265
Epoch 193/800
36/36 [==============================] - 0s 598us/step - loss: 0.0268
Epoch 194/800
36/36 [==============================] - 0s 418us/step - loss: 0.0284
Epoch 195/800
36/36 [==============================] - 0s 312us/step - loss: 0.0268
Epoch 196/800
36/36 [==============================] - 0s 305us/step - loss: 0.0252
Epoch 197/800
36/36 [==============================] - 0s 255us/step - loss: 0.0275
Epoch 198/800
36/36 [==============================] - 0s 272us/step - loss: 0.0304
Epoch 199/800
36/36 [==============================] - 0s 302us/step - loss: 0.0259
Epoch 200/800
36/36 [==============================] - 0s 285us/step - loss: 0.0278
Epoch 201/800
36/36 [==============================] - 0s 316us/step - loss: 0.0278
Epoch 202/800
36/36 [==============================] - 0s 314us/step - loss: 0.0255
Epoch 203/800
36/36 [==============================] - 0s 306us/step - loss: 0.0281
Epoch 204/800
36/36 [==============================] - 0s 499us/step - loss: 0.0262
Epoch 205/800
36/36 [==============================] - 0s 416us/step - loss: 0.0280
```

```
Epoch 206/800
36/36 [==============================] - 0s 326us/step - loss: 0.0260
Epoch 207/800
36/36 [==============================] - 0s 317us/step - loss: 0.0328
Epoch 208/800
36/36 [==============================] - 0s 332us/step - loss: 0.0277
Epoch 209/800
36/36 [==============================] - 0s 485us/step - loss: 0.0279
Epoch 210/800
36/36 [==============================] - 0s 370us/step - loss: 0.0276
Epoch 211/800
36/36 [==============================] - 0s 322us/step - loss: 0.0277
Epoch 212/800
36/36 [==============================] - 0s 372us/step - loss: 0.0270
Epoch 213/800
36/36 [==============================] - 0s 343us/step - loss: 0.0291
Epoch 214/800
36/36 [==============================] - 0s 294us/step - loss: 0.0275
Epoch 215/800
36/36 [==============================] - 0s 332us/step - loss: 0.0249
Epoch 216/800
36/36 [==============================] - 0s 259us/step - loss: 0.0301
Epoch 217/800
36/36 [==============================] - 0s 427us/step - loss: 0.0269
Epoch 218/800
36/36 [==============================] - 0s 333us/step - loss: 0.0271
Epoch 219/800
36/36 [==============================] - 0s 320us/step - loss: 0.0280
Epoch 220/800
36/36 [==============================] - 0s 411us/step - loss: 0.0274
Epoch 221/800
36/36 [==============================] - 0s 500us/step - loss: 0.0271
Epoch 222/800
36/36 [==============================] - 0s 713us/step - loss: 0.0279
Epoch 223/800
36/36 [==============================] - 0s 643us/step - loss: 0.0308
Epoch 224/800
36/36 [==============================] - 0s 450us/step - loss: 0.0269
Epoch 225/800
36/36 [==============================] - 0s 334us/step - loss: 0.0250
Epoch 226/800
36/36 [==============================] - 0s 326us/step - loss: 0.0256
Epoch 227/800
36/36 [==============================] - 0s 311us/step - loss: 0.0278
Epoch 228/800
36/36 [==============================] - 0s 295us/step - loss: 0.0293
Epoch 229/800
36/36 [==============================] - 0s 320us/step - loss: 0.0263
Epoch 230/800
36/36 [==============================] - 0s 300us/step - loss: 0.0254
Epoch 231/800
36/36 [==============================] - 0s 385us/step - loss: 0.0257
Epoch 232/800
36/36 [==============================] - 0s 291us/step - loss: 0.0308
Epoch 233/800
36/36 [==============================] - 0s 355us/step - loss: 0.0279
Epoch 234/800
```

```
36/36 [==============================] - 0s 327us/step - loss: 0.0255
Epoch 235/800
36/36 [==============================] - 0s 321us/step - loss: 0.0266
Epoch 236/800
36/36 [==============================] - 0s 276us/step - loss: 0.0280
Epoch 237/800
36/36 [==============================] - 0s 290us/step - loss: 0.0262
Epoch 238/800
36/36 [==============================] - 0s 271us/step - loss: 0.0267
Epoch 239/800
36/36 [==============================] - 0s 294us/step - loss: 0.0272
Epoch 240/800
36/36 [==============================] - 0s 355us/step - loss: 0.0278
Epoch 241/800
36/36 [==============================] - 0s 467us/step - loss: 0.0264
Epoch 242/800
36/36 [==============================] - 0s 334us/step - loss: 0.0255
Epoch 243/800
36/36 [==============================] - 0s 331us/step - loss: 0.0277
Epoch 244/800
36/36 [==============================] - 0s 289us/step - loss: 0.0267
Epoch 245/800
36/36 [==============================] - 0s 293us/step - loss: 0.0316
Epoch 246/800
36/36 [==============================] - 0s 278us/step - loss: 0.0261
Epoch 247/800
36/36 [==============================] - 0s 310us/step - loss: 0.0307
Epoch 248/800
36/36 [==============================] - 0s 349us/step - loss: 0.0250
Epoch 249/800
36/36 [==============================] - 0s 335us/step - loss: 0.0266
Epoch 250/800
36/36 [==============================] - ETA: 0s - loss: 0.024 - 0s 301us/step
- loss: 0.0253
Epoch 251/800
36/36 [==============================] - 0s 527us/step - loss: 0.0274
Epoch 252/800
36/36 [==============================] - 0s 537us/step - loss: 0.0271
Epoch 253/800
36/36 [==============================] - 0s 553us/step - loss: 0.0278
Epoch 254/800
36/36 [==============================] - 0s 713us/step - loss: 0.0273
Epoch 255/800
36/36 [==============================] - 0s 596us/step - loss: 0.0300
Epoch 256/800
36/36 [==============================] - 0s 789us/step - loss: 0.0267
Epoch 257/800
36/36 [==============================] - 0s 388us/step - loss: 0.0280
Epoch 258/800
36/36 [==============================] - 0s 530us/step - loss: 0.0261
Epoch 259/800
36/36 [==============================] - 0s 369us/step - loss: 0.0260
Epoch 260/800
36/36 [==============================] - 0s 385us/step - loss: 0.0265
Epoch 261/800
36/36 [==============================] - 0s 417us/step - loss: 0.0262
Epoch 262/800
```

```
36/36 [==============================] - 0s 357us/step - loss: 0.0281
Epoch 263/800
36/36 [==============================] - 0s 641us/step - loss: 0.0279
Epoch 264/800
36/36 [==============================] - 0s 494us/step - loss: 0.0276
Epoch 265/800
36/36 [==============================] - 0s 642us/step - loss: 0.0279
Epoch 266/800
36/36 [==============================] - 0s 548us/step - loss: 0.0283
Epoch 267/800
36/36 [==============================] - 0s 584us/step - loss: 0.0283
Epoch 268/800
36/36 [==============================] - 0s 482us/step - loss: 0.0302
Epoch 269/800
36/36 [==============================] - 0s 715us/step - loss: 0.0281
Epoch 270/800
36/36 [==============================] - 0s 322us/step - loss: 0.0255
Epoch 271/800
36/36 [==============================] - 0s 336us/step - loss: 0.0258
Epoch 272/800
36/36 [==============================] - 0s 372us/step - loss: 0.0253
Epoch 273/800
36/36 [==============================] - 0s 453us/step - loss: 0.0248
Epoch 274/800
36/36 [==============================] - 0s 277us/step - loss: 0.0249
Epoch 275/800
36/36 [==============================] - 0s 431us/step - loss: 0.0320
Epoch 276/800
36/36 [==============================] - 0s 283us/step - loss: 0.0298
Epoch 277/800
36/36 [==============================] - 0s 267us/step - loss: 0.0280
Epoch 278/800
36/36 [==============================] - 0s 456us/step - loss: 0.0270
Epoch 279/800
36/36 [==============================] - 0s 360us/step - loss: 0.0250
Epoch 280/800
36/36 [==============================] - 0s 410us/step - loss: 0.0243
Epoch 281/800
36/36 [==============================] - 0s 294us/step - loss: 0.0264
Epoch 282/800
36/36 [==============================] - 0s 308us/step - loss: 0.0274
Epoch 283/800
36/36 [==============================] - 0s 590us/step - loss: 0.0274
Epoch 284/800
36/36 [==============================] - 0s 471us/step - loss: 0.0276
Epoch 285/800
36/36 [==============================] - 0s 501us/step - loss: 0.0274
Epoch 286/800
36/36 [==============================] - 0s 467us/step - loss: 0.0272
Epoch 287/800
36/36 [==============================] - 0s 517us/step - loss: 0.0281
Epoch 288/800
36/36 [==============================] - 0s 736us/step - loss: 0.0274
Epoch 289/800
36/36 [==============================] - 0s 473us/step - loss: 0.0276
Epoch 290/800
36/36 [==============================] - 0s 486us/step - loss: 0.0268
```

```
Epoch 291/800
36/36 [==============================] - ETA: 0s - loss: 0.028 - 0s 327us/step
- loss: 0.0261
Epoch 292/800
36/36 [==============================] - 0s 324us/step - loss: 0.0327
Epoch 293/800
36/36 [==============================] - 0s 351us/step - loss: 0.0265
Epoch 294/800
36/36 [==============================] - 0s 530us/step - loss: 0.0256
Epoch 295/800
36/36 [==============================] - 0s 505us/step - loss: 0.0247
Epoch 296/800
36/36 [==============================] - 0s 517us/step - loss: 0.0303
Epoch 297/800
36/36 [==============================] - 0s 479us/step - loss: 0.0261
Epoch 298/800
36/36 [==============================] - 0s 647us/step - loss: 0.0273
Epoch 299/800
36/36 [==============================] - 0s 627us/step - loss: 0.0277
Epoch 300/800
36/36 [==============================] - 0s 704us/step - loss: 0.0244
Epoch 301/800
36/36 [==============================] - 0s 580us/step - loss: 0.0286
Epoch 302/800
36/36 [==============================] - 0s 457us/step - loss: 0.0282
Epoch 303/800
36/36 [==============================] - 0s 427us/step - loss: 0.0319
Epoch 304/800
36/36 [==============================] - 0s 464us/step - loss: 0.0249
Epoch 305/800
36/36 [==============================] - 0s 377us/step - loss: 0.0249
Epoch 306/800
36/36 [==============================] - 0s 428us/step - loss: 0.0264
Epoch 307/800
36/36 [==============================] - 0s 304us/step - loss: 0.0254
Epoch 308/800
36/36 [==============================] - 0s 342us/step - loss: 0.0295
Epoch 309/800
36/36 [==============================] - 0s 272us/step - loss: 0.0257
Epoch 310/800
36/36 [==============================] - 0s 327us/step - loss: 0.0249
Epoch 311/800
36/36 [==============================] - 0s 479us/step - loss: 0.0242
Epoch 312/800
36/36 [==============================] - 0s 328us/step - loss: 0.0288
Epoch 313/800
36/36 [==============================] - 0s 266us/step - loss: 0.0271
Epoch 314/800
36/36 [==============================] - 0s 340us/step - loss: 0.0250
Epoch 315/800
36/36 [==============================] - 0s 311us/step - loss: 0.0279
Epoch 316/800
36/36 [==============================] - 0s 299us/step - loss: 0.0258
Epoch 317/800
36/36 [==============================] - 0s 308us/step - loss: 0.0274
Epoch 318/800
36/36 [==============================] - 0s 390us/step - loss: 0.0260
```

```
Epoch 319/800
36/36 [==============================] - 0s 339us/step - loss: 0.0270
Epoch 320/800
36/36 [==============================] - 0s 304us/step - loss: 0.0265
Epoch 321/800
36/36 [==============================] - 0s 373us/step - loss: 0.0251
Epoch 322/800
36/36 [==============================] - 0s 289us/step - loss: 0.0261
Epoch 323/800
36/36 [==============================] - 0s 332us/step - loss: 0.0266
Epoch 324/800
36/36 [==============================] - 0s 410us/step - loss: 0.0292
Epoch 325/800
36/36 [==============================] - 0s 404us/step - loss: 0.0256
Epoch 326/800
36/36 [==============================] - 0s 363us/step - loss: 0.0284
Epoch 327/800
36/36 [==============================] - 0s 307us/step - loss: 0.0250
Epoch 328/800
36/36 [==============================] - 0s 333us/step - loss: 0.0303
Epoch 329/800
36/36 [==============================] - 0s 418us/step - loss: 0.0246
Epoch 330/800
36/36 [==============================] - 0s 307us/step - loss: 0.0287
Epoch 331/800
36/36 [==============================] - 0s 318us/step - loss: 0.0302
Epoch 332/800
36/36 [==============================] - 0s 318us/step - loss: 0.0259
Epoch 333/800
36/36 [==============================] - 0s 338us/step - loss: 0.0278
Epoch 334/800
36/36 [==============================] - 0s 308us/step - loss: 0.0259
Epoch 335/800
36/36 [==============================] - 0s 324us/step - loss: 0.0297
Epoch 336/800
36/36 [==============================] - 0s 365us/step - loss: 0.0269
Epoch 337/800
36/36 [==============================] - 0s 312us/step - loss: 0.0270
Epoch 338/800
36/36 [==============================] - 0s 338us/step - loss: 0.0299
Epoch 339/800
36/36 [==============================] - 0s 311us/step - loss: 0.0254
Epoch 340/800
36/36 [==============================] - 0s 344us/step - loss: 0.0247
Epoch 341/800
36/36 [==============================] - 0s 395us/step - loss: 0.0263
Epoch 342/800
36/36 [==============================] - 0s 486us/step - loss: 0.0249
Epoch 343/800
36/36 [==============================] - 0s 492us/step - loss: 0.0261
Epoch 344/800
36/36 [==============================] - 0s 652us/step - loss: 0.0244
Epoch 345/800
36/36 [==============================] - 0s 435us/step - loss: 0.0312
Epoch 346/800
36/36 [==============================] - 0s 400us/step - loss: 0.0272
Epoch 347/800
```

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36/36 [==============================] - 0s 346us/step - loss: 0.0263
Epoch 348/800
36/36 [==============================] - 0s 391us/step - loss: 0.0248
Epoch 349/800
36/36 [==============================] - 0s 315us/step - loss: 0.0271
Epoch 350/800
36/36 [==============================] - 0s 301us/step - loss: 0.0251
Epoch 351/800
36/36 [==============================] - 0s 296us/step - loss: 0.0279
Epoch 352/800
36/36 [==============================] - 0s 262us/step - loss: 0.0271
Epoch 353/800
36/36 [==============================] - 0s 350us/step - loss: 0.0269
Epoch 354/800
36/36 [==============================] - 0s 276us/step - loss: 0.0272
Epoch 355/800
36/36 [==============================] - 0s 566us/step - loss: 0.0261
Epoch 356/800
36/36 [==============================] - 0s 632us/step - loss: 0.0333
Epoch 357/800
36/36 [==============================] - 0s 579us/step - loss: 0.0260
Epoch 358/800
36/36 [==============================] - 0s 541us/step - loss: 0.0258
Epoch 359/800
36/36 [==============================] - 0s 714us/step - loss: 0.0253
Epoch 360/800
36/36 [==============================] - 0s 466us/step - loss: 0.0278
Epoch 361/800
36/36 [==============================] - 0s 542us/step - loss: 0.0256
Epoch 362/800
36/36 [==============================] - 0s 417us/step - loss: 0.0262
Epoch 363/800
36/36 [==============================] - 0s 613us/step - loss: 0.0245
Epoch 364/800
36/36 [==============================] - 0s 371us/step - loss: 0.0280
Epoch 365/800
36/36 [==============================] - 0s 324us/step - loss: 0.0269
Epoch 366/800
36/36 [==============================] - 0s 515us/step - loss: 0.0265
Epoch 367/800
36/36 [==============================] - 0s 372us/step - loss: 0.0268
Epoch 368/800
36/36 [==============================] - 0s 476us/step - loss: 0.0254
Epoch 369/800
36/36 [==============================] - 0s 370us/step - loss: 0.0249
Epoch 370/800
36/36 [==============================] - 0s 381us/step - loss: 0.0250
Epoch 371/800
36/36 [==============================] - 0s 485us/step - loss: 0.0265
Epoch 372/800
36/36 [==============================] - 0s 386us/step - loss: 0.0255
Epoch 373/800
36/36 [==============================] - 0s 363us/step - loss: 0.0273
Epoch 374/800
36/36 [==============================] - 0s 408us/step - loss: 0.0295
Epoch 375/800
36/36 [==============================] - 0s 406us/step - loss: 0.0258
```

```
Epoch 376/800
36/36 [==============================] - 0s 327us/step - loss: 0.0277
Epoch 377/800
36/36 [==============================] - 0s 344us/step - loss: 0.0245
Epoch 378/800
36/36 [==============================] - 0s 387us/step - loss: 0.0285
Epoch 379/800
36/36 [==============================] - 0s 422us/step - loss: 0.0267
Epoch 380/800
36/36 [==============================] - 0s 576us/step - loss: 0.0265
Epoch 381/800
36/36 [==============================] - 0s 501us/step - loss: 0.0271
Epoch 382/800
36/36 [==============================] - 0s 465us/step - loss: 0.0245
Epoch 383/800
36/36 [==============================] - 0s 686us/step - loss: 0.0264
Epoch 384/800
36/36 [==============================] - 0s 462us/step - loss: 0.0276
Epoch 385/800
36/36 [==============================] - 0s 472us/step - loss: 0.0270
Epoch 386/800
36/36 [==============================] - 0s 535us/step - loss: 0.0262
Epoch 387/800
36/36 [==============================] - 0s 558us/step - loss: 0.0304
Epoch 388/800
36/36 [==============================] - 0s 325us/step - loss: 0.0265
Epoch 389/800
36/36 [==============================] - 0s 476us/step - loss: 0.0286
Epoch 390/800
36/36 [==============================] - 0s 374us/step - loss: 0.0249
Epoch 391/800
36/36 [==============================] - 0s 356us/step - loss: 0.0277
Restoring model weights from the end of the best epoch
Epoch 00391: early stopping
best epoch =  311
smallest loss = 0.02421319277750121
```

In [10]:

```
# Task 2.2 Part e

# This line of code can be used to reconstruct the saved model. The name of t
recon_model4 = keras.models.load_model("best_model4")

import matplotlib.pyplot as plt

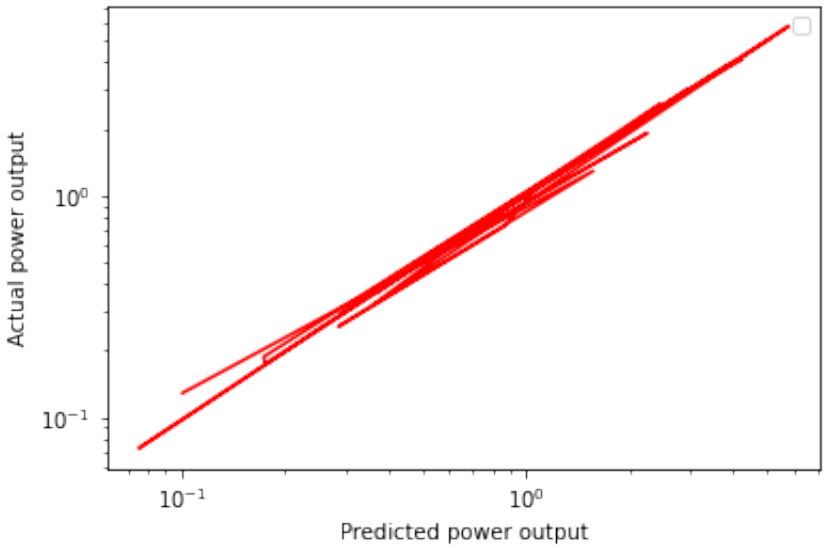
y_predictp = []
y_testp = []
Wdotpredp = []
Wdotorigp = []

for i in range(len(X_train3)):
    testp = [[X_train3[i][0], X_train3[i][1], X_train3[i][2], X_train3[i][3]]
    testarrayp = np.array(testp)
    a3 = recon_model4.predict(testarrayp)
    y_predictp.append([a3[0][0], a3[0][1]])
    y_testp.append([y_train3[i][0], y_train3[i][1]])
    Wdotpredp.append([a3[0][1]])
    Wdotorigp.append([y_train3[i][1]])

plt.figure()
plt.loglog(Wdotpredp, Wdotorigp, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
fig.tight_layout()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(y_predictp[:][1],y_testp[:][1])
mae_Vl = metrics.mean_absolute_error(y_predictp[:][0],y_testp[:][0])
print('mean absolute error between predictions and the collection of test dat
```

```
No handles with labels found to put in legend.
```




```
mean absolute error between predictions and the collection of test data: Vl =
0.0161700453573944  Wdot =  0.13746684174071533
```

In [347…

```
# Task 2.2 Part f

# This line of code can be used to reconstruct the saved model. The name of t
recon_model4 = keras.models.load_model("best_model4")

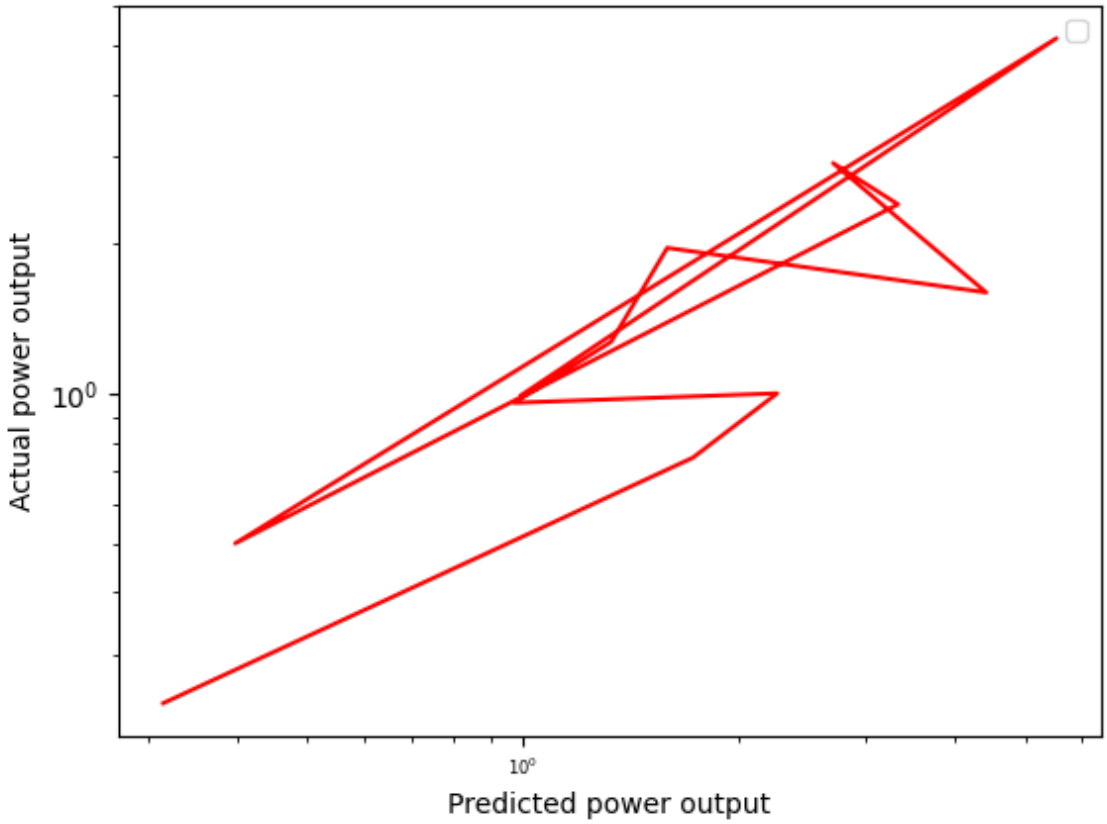
import matplotlib.pyplot as plt

y_predictpn = []
y_testpn = []
Wdotpredpn = []
Wdotorigpn = []

for i in range(len(X_test3)):
    testp = [[X_test3[i][0], X_test3[i][1], X_test3[i][2], X_test3[i][3]]]
    testarrayp = np.array(testp)
    a3 = recon_model4.predict(testarrayp)
    y_predictpn.append([a3[0][0], a3[0][1]])
    y_testpn.append([y_test3[i][0], y_test3[i][1]])
    Wdotpredpn.append([a3[0][1]])
    Wdotorigpn.append([y_test3[i][1]])

plt.figure()
plt.loglog(Wdotpredpn, Wdotorigpn, c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted power output")
plt.ylabel("Actual power output")
plt.legend()
plt.show()

#MAE of predicted vs test data
mae_Wdot = metrics.mean_absolute_error(y_predictpn[:][1],y_testpn[:][1])
mae_Vl = metrics.mean_absolute_error(y_predictpn[:][0],y_testpn[:][0])
print('mean absolute error between predictions and the collection of test dat
```




```
No handles with labels found to put in legend.
mean absolute error between predictions and the collection of test data: Vl =
0.01038831024423309  Wdot =  0.20072558901527193
```

In [312…

```
#Task 2.2 Part g (i)
xtestdata = [[10.0, 200, 50],
[20.0, 200, 130],
[10.0, 500, 40],
[20.0, 500, 80],
[20.0, 700, 30],
[20.0, 700, 55],
[10.0, 1000, 12],
[20.0, 1000, 25],
[20.0, 1000, 39]]

Tairx =[]
Idx =[]
Rlx =[]

for x in range(len(xtestdata)):
    Tairx.append(xtestdata[x][0])
    Idx.append(xtestdata[x][1])
    Rlx.append(xtestdata[x][2])

Tairg = Tairx/medTairm
Idg = Idx/medIdm
Rlg = Rlx/medRlm

xarrayg = np.column_stack((Tairg, Idg, Rlg))

print(xarrayg)
```

```
[[1.         0.28571429 1.68350168]
 [2.         0.28571429 4.37710438]
 [1.         0.71428571 1.34680135]
 [2.         0.71428571 2.69360269]
 [2.         1.         1.01010101]
 [2.         1.         1.85185185]
 [1.         1.42857143 0.4040404 ]
 [2.         1.42857143 0.84175084]
 [2.         1.42857143 1.31313131]]
```

In [326…

```
# Task 2.2 part g(i) predict

# This line of code can be used to reconstruct the saved model. The name of t
recon_model3 = keras.models.load_model("best_model3")

import matplotlib.pyplot as plt

Mmaxg = []
Vlg = []
Wdotg = []

for i in range(len(xarrayg)):
    testg = [[xarrayg[i][0], xarrayg[i][1], xarrayg[i][2]]]
    testarrayg = np.array(testg)
    a3 = recon_model3.predict(testarrayg)
    Mmaxg.append(a3[0][0]*medMmaxm)
    Vlg.append(a3[0][1]*medVlm)
    Wdotg.append(a3[0][2]*medRlm)

titles = ['Tair', 'I_D', 'R_L', 'Mmax','V_L','Wdot']
data = [titles] + list(zip(Tairx, Idx, Rlx, Mmaxg, Vlg, Wdotg))

for i, d in enumerate(data):
    line = '|'.join(str(x).ljust(12) for x in d)
    print(line)
    if i == 0:
        print('-' * len(line))
```

```
Tair        |I_D         |R_L         |Mmax        |V_L         |Wdot
------------------------------------------------------------------------------
10.0        |200         |50          |1.960221290588379|89.8546043753624|9.89
9569237232209
20.0        |200         |130         |3.122393488883972|147.61776564121246|10
.749907332658767
10.0        |500         |40          |2.7385908365249634|123.95160114765167|2
2.106579428911207
20.0        |500         |80          |3.0291666984558105|196.10980958938597|2
7.262160074710845
20.0        |700         |30          |2.7685380578041077|139.9828702688217|33
.15414147377014
20.0        |700         |55          |3.175045609474182|199.35400216579436|36
.27611528635025
10.0        |1000        |12          |1.8894925117492676|95.91855140924453|46
.14515111446381
20.0        |1000        |25          |2.8598315119743347|156.90542230606079|5
1.35843331813812
20.0        |1000        |39          |3.335097312927246|203.77947695255278|53
.72723318338394
```

In [336…

```
#Task 2.2 Part g (ii)
Mmaxr = np.round(Mmaxg)
Mmaxrg = Mmaxr/medMp
Tairrg = Tairx/medTairp
Idrg = Idx/medIdp
Rlrg = Rlx/medRlp

xtestg = np.column_stack((Mmaxrg, Tairrg, Idrg, Rlrg))
print(xtestg)
```

```
[[1.         1.         0.33333333 1.82149362]
 [1.5        2.         0.33333333 4.73588342]
 [1.5        1.         0.83333333 1.4571949 ]
 [1.5        2.         0.83333333 2.9143898 ]
 [1.5        2.         1.16666667 1.09289617]
 [1.5        2.         1.16666667 2.00364299]
 [1.         1.         1.66666667 0.43715847]
 [1.5        2.         1.66666667 0.91074681]
 [1.5        2.         1.66666667 1.42076503]]
```

In [348…

```
# Task 2.2 part g(ii) predict

# This line of code can be used to reconstruct the saved model. The name of t
recon_model4 = keras.models.load_model("best_model4")

import matplotlib.pyplot as plt

Vlg2 = []
Wdotg2 = []

for i in range(len(xtestg)):
    testg = [[xtestg[i][0], xtestg[i][1], xtestg[i][2], xtestg[i][3]]]
    testarrayg = np.array(testg)
    a3 = recon_model4.predict(testarrayg)
    Vlg2.append(a3[0][0]*medVlp)
    Wdotg2.append(a3[0][1]*medRlp)

mae_Wdot = metrics.mean_absolute_error(Wdotg,Wdotg2)

titles = ['Mmax_round', 'Tair', 'I_D', 'R_L', 'V_L', 'Wdot']
data = [titles] + list(zip(Mmaxr, Tairx, Idx, Rlx, Vlg2, Wdotg2))

for i, d in enumerate(data):
    line = '|'.join(str(x).ljust(12) for x in d)
    print(line)
    if i == 0:
        print('-' * len(line))
print('mean absolute error between predictions from first and second model: W
```

```
Mmax_round  |Tair        |I_D         |R_L         |V_L         |Wdot
-------------------------------------------------------------------------------
2.0         |10.0        |200         |50          |91.62284830808639|27.14180
871248245
3.0         |20.0        |200         |130         |161.88119632005692|23.5202
06040143965
3.0         |10.0        |500         |40          |114.02570812702179|54.8154
17718887325
3.0         |20.0        |500         |80          |148.4456235408783|32.26498
575210571
3.0         |20.0        |700         |30          |67.31403270959854|21.85776
7286896706
3.0         |20.0        |700         |55          |137.04444386959076|47.8408
31798315044
2.0         |10.0        |1000        |12          |105.40879675149917|151.831
032371521
3.0         |20.0        |1000        |25          |116.42981876134873|69.3845
32392025
3.0         |20.0        |1000        |39          |180.83092231750487|102.592
18779802322
mean absolute error between predictions from first and second model: Wdot = 29
.240247532725334
```