Resnet Mode

In [ ]:
```
import tensorflow as tf
from tensorflow.keras.layers import Input, Add, Dense, Layer
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam

class H1Layer(Layer):
    def __init__(self, **kwargs):
        super(H1Layer, self).__init__(**kwargs)

    def build(self, input_shape):
        self.b = self.add_weight(shape=(input_shape[-1],),
                                 initializer='random_normal',
                                 trainable=True)
        super(H1Layer, self).build(input_shape)

    def call(self, x):
        return self.b * (2 * x)
        #return (2 * x)


class H2Layer(Layer):
    def __init__(self, h1, **kwargs):
        super(H2Layer, self).__init__(**kwargs)
        self.h1 = h1

    def call(self, x):
        return (2*x*(self.h1(x)))-2

class H3Layer(Layer):
    def __init__(self, h2, **kwargs):
        super(H3Layer, self).__init__(**kwargs)
        self.h2 = h2

    def call(self, x):
        return (2*x*(self.h2(x)))-(4*self.h2(x))

class H4Layer(Layer):
    def __init__(self, h3, **kwargs):
        super(H4Layer, self).__init__(**kwargs)
        self.h3 = h3

    def call(self, x):
        return (2*x*(self.h3(x)))-(6*self.h3(x))

class TensorDecompositionLayer(Layer):
    def __init__(self, rank, **kwargs):
        self.rank = rank
        super(TensorDecompositionLayer, self).__init__(**kwargs)

    def build(self, input_shape):
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        self.factors_a = self.add_weight(shape=(input_shape[-1], self.rank),
                                         initializer='random_normal',
                                         trainable=True)
        self.factors_b = self.add_weight(shape=(self.rank, input_shape[-1]),
                                         initializer='random_normal',
                                         trainable=True)
        super(TensorDecompositionLayer, self).build(input_shape)

    def call(self, x):
        return tf.matmul(tf.matmul(x, self.factors_a), self.factors_b)

def polynomial_activation(x, degree=1):
    if degree == 1:
        return x
    elif degree == 2:
        return x * x
    elif degree == 3:
        return x**3
    elif degree ==4:
        return x**4
    else:
        raise ValueError("Invalid degree specified, only 1st, 2nd and 3rd degree po

def resnet_block(x, filters, activation_1, activation_2, rank=None):

    h1 = H1Layer()
    h2 = H2Layer(h1)
    x = Dense(filters)(x)
    x = h2(x)
    x = Dense(filters)(x)
    return x

def build_model(input_shape, num_blocks, filters, activation_1, activation_2, rank=
    input_layer = Input(shape=input_shape)
    x = input_layer

    for _ in range(num_blocks):
        x = resnet_block(x, filters, activation_1, activation_2, rank)

    output_layer = Dense(1)(x)
    model = Model(inputs=input_layer, outputs=output_layer)

    return model

input_shape = (1,)
num_blocks = 3
filters = 16
# activation_1 = tf.keras.activations.relu
activation_1 = lambda x: polynomial_activation(x, degree=1)
#activation_2 = tf.keras.activations.linear
activation_2 = lambda x: polynomial_activation(x, degree=1)

rank = 2

model = build_model(input_shape, num_blocks, filters, activation_1, activation_2, r
```

```
optimizer = Adam(learning_rate=0.00001) # Reduce learning rate
model.compile(optimizer='adam', loss='mse')
```

- Just uses up to n= 2
- When applied Higher values explode and predictions become NAN
- Just trained for 300 epochs, good results appear before 100

In [ ]:
```
import numpy as np

np.random.seed(42)
n_samples = 10000
lower_bound = -2 * np.pi
upper_bound = 2 * np.pi
#lower_bound = -10
#upper_bound = 10

X = np.random.uniform(lower_bound, upper_bound, size=(n_samples, 1))
y = np.cos(X)

from sklearn.model_selection import train_test_split

X_train, X_val, y_train, y_val = train_test_split(X, y, test_size=0.2, random_state

batch_size = 64
epochs = 300

history = model.fit(X_train, y_train,
                    batch_size=batch_size,
                    epochs=epochs,
                    verbose=1,
                    validation_data=(X_val, y_val))
```

```
Epoch 1/300
125/125 [==============================] - 1s 2ms/step - loss: 0.1730 - val_loss: 3.
9989e-04
Epoch 2/300
125/125 [==============================] - 0s 964us/step - loss: 2.9773e-04 - val_lo
ss: 2.5815e-04
Epoch 3/300
125/125 [==============================] - 0s 972us/step - loss: 2.0898e-04 - val_lo
ss: 1.9536e-04
Epoch 4/300
125/125 [==============================] - 0s 956us/step - loss: 3.9800e-04 - val_lo
ss: 2.2846e-04
Epoch 5/300
125/125 [==============================] - 0s 939us/step - loss: 2.4234e-04 - val_lo
ss: 2.2109e-04
Epoch 6/300
125/125 [==============================] - 0s 985us/step - loss: 3.6755e-04 - val_lo
ss: 1.9032e-04
Epoch 7/300
125/125 [==============================] - 0s 948us/step - loss: 2.4413e-04 - val_lo
ss: 2.9657e-04
Epoch 8/300
125/125 [==============================] - 0s 938us/step - loss: 3.5292e-04 - val_lo
ss: 2.3761e-04
Epoch 9/300
125/125 [==============================] - 0s 936us/step - loss: 5.9089e-04 - val_lo
ss: 7.3954e-04
Epoch 10/300
125/125 [==============================] - 0s 924us/step - loss: 0.0020 - val_loss:
9.9799e-04
Epoch 11/300
125/125 [==============================] - 0s 960us/step - loss: 3.5890e-04 - val_lo
ss: 3.2174e-04
Epoch 12/300
125/125 [==============================] - 0s 952us/step - loss: 2.5961e-04 - val_lo
ss: 2.9682e-04
Epoch 13/300
125/125 [==============================] - 0s 939us/step - loss: 2.8830e-04 - val_lo
ss: 2.7721e-04
Epoch 14/300
125/125 [==============================] - 0s 924us/step - loss: 5.3848e-04 - val_lo
ss: 1.9927e-04
Epoch 15/300
125/125 [==============================] - 0s 919us/step - loss: 2.5061e-04 - val_lo
ss: 2.2289e-04
Epoch 16/300
125/125 [==============================] - 0s 925us/step - loss: 4.1236e-04 - val_lo
ss: 2.4305e-04
Epoch 17/300
125/125 [==============================] - 0s 923us/step - loss: 5.8988e-04 - val_lo
ss: 4.3881e-04
Epoch 18/300
125/125 [==============================] - 0s 912us/step - loss: 9.7025e-04 - val_lo
ss: 2.9173e-04
Epoch 19/300
125/125 [==============================] - 0s 928us/step - loss: 3.9336e-04 - val_lo
```

```
ss: 0.0011
Epoch 20/300
125/125 [==============================] - 0s 928us/step - loss: 4.4272e-04 - val_lo
ss: 3.1900e-04
Epoch 21/300
125/125 [==============================] - 0s 922us/step - loss: 7.5101e-04 - val_lo
ss: 3.0187e-04
Epoch 22/300
125/125 [==============================] - 0s 923us/step - loss: 2.8521e-04 - val_lo
ss: 2.3844e-04
Epoch 23/300
125/125 [==============================] - 0s 920us/step - loss: 8.8484e-04 - val_lo
ss: 4.3095e-04
Epoch 24/300
125/125 [==============================] - 0s 924us/step - loss: 3.6323e-04 - val_lo
ss: 3.0362e-04
Epoch 25/300
125/125 [==============================] - 0s 952us/step - loss: 4.3225e-04 - val_lo
ss: 3.2856e-04
Epoch 26/300
125/125 [==============================] - 0s 926us/step - loss: 2.9694e-04 - val_lo
ss: 4.5812e-04
Epoch 27/300
125/125 [==============================] - 0s 927us/step - loss: 5.0007e-04 - val_lo
ss: 4.1298e-04
Epoch 28/300
125/125 [==============================] - 0s 922us/step - loss: 6.3055e-04 - val_lo
ss: 7.0030e-04
Epoch 29/300
125/125 [==============================] - 0s 933us/step - loss: 7.5547e-04 - val_lo
ss: 3.1821e-04
Epoch 30/300
125/125 [==============================] - 0s 927us/step - loss: 4.6930e-04 - val_lo
ss: 2.7011e-04
Epoch 31/300
125/125 [==============================] - 0s 948us/step - loss: 7.1983e-04 - val_lo
ss: 2.4967e-04
Epoch 32/300
125/125 [==============================] - 0s 933us/step - loss: 3.6243e-04 - val_lo
ss: 1.7664e-04
Epoch 33/300
125/125 [==============================] - 0s 922us/step - loss: 3.0008e-04 - val_lo
ss: 2.5729e-04
Epoch 34/300
125/125 [==============================] - 0s 934us/step - loss: 4.3714e-04 - val_lo
ss: 3.9529e-04
Epoch 35/300
125/125 [==============================] - 0s 920us/step - loss: 6.1088e-04 - val_lo
ss: 8.7878e-04
Epoch 36/300
125/125 [==============================] - 0s 930us/step - loss: 4.2975e-04 - val_lo
ss: 2.3609e-04
Epoch 37/300
125/125 [==============================] - 0s 938us/step - loss: 5.0713e-04 - val_lo
ss: 2.2606e-04
Epoch 38/300
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125/125 [==============================] - 0s 928us/step - loss: 3.4652e-04 - val_lo
ss: 2.9346e-04
Epoch 39/300
125/125 [==============================] - 0s 932us/step - loss: 0.0010 - val_loss:
2.6308e-04
Epoch 40/300
125/125 [==============================] - 0s 940us/step - loss: 9.1926e-04 - val_lo
ss: 2.0870e-04
Epoch 41/300
125/125 [==============================] - 0s 935us/step - loss: 3.6899e-04 - val_lo
ss: 2.3082e-04
Epoch 42/300
125/125 [==============================] - 0s 929us/step - loss: 2.9044e-04 - val_lo
ss: 1.9689e-04
Epoch 43/300
125/125 [==============================] - 0s 930us/step - loss: 3.3267e-04 - val_lo
ss: 3.3106e-04
Epoch 44/300
125/125 [==============================] - 0s 924us/step - loss: 3.8951e-04 - val_lo
ss: 2.6976e-04
Epoch 45/300
125/125 [==============================] - 0s 936us/step - loss: 3.6311e-04 - val_lo
ss: 6.8533e-04
Epoch 46/300
125/125 [==============================] - 0s 933us/step - loss: 7.7206e-04 - val_lo
ss: 2.3376e-04
Epoch 47/300
125/125 [==============================] - 0s 939us/step - loss: 4.1997e-04 - val_lo
ss: 3.1570e-04
Epoch 48/300
125/125 [==============================] - 0s 927us/step - loss: 0.0010 - val_loss:
5.9289e-04
Epoch 49/300
125/125 [==============================] - 0s 920us/step - loss: 4.5257e-04 - val_lo
ss: 3.0997e-04
Epoch 50/300
125/125 [==============================] - 0s 924us/step - loss: 4.3469e-04 - val_lo
ss: 3.2725e-04
Epoch 51/300
125/125 [==============================] - 0s 924us/step - loss: 3.2695e-04 - val_lo
ss: 5.5215e-04
Epoch 52/300
125/125 [==============================] - 0s 984us/step - loss: 4.3579e-04 - val_lo
ss: 3.0774e-04
Epoch 53/300
125/125 [==============================] - 0s 926us/step - loss: 3.2317e-04 - val_lo
ss: 2.3617e-04
Epoch 54/300
125/125 [==============================] - 0s 922us/step - loss: 3.7662e-04 - val_lo
ss: 2.5875e-04
Epoch 55/300
125/125 [==============================] - 0s 925us/step - loss: 4.5121e-04 - val_lo
ss: 0.0011
Epoch 56/300
125/125 [==============================] - 0s 924us/step - loss: 6.2314e-04 - val_lo
ss: 0.0040
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Epoch 57/300
125/125 [==============================] - 0s 932us/step - loss: 8.2532e-04 - val_lo
ss: 2.0359e-04
Epoch 58/300
125/125 [==============================] - 0s 920us/step - loss: 4.4044e-04 - val_lo
ss: 0.0024
Epoch 59/300
125/125 [==============================] - 0s 925us/step - loss: 8.9152e-04 - val_lo
ss: 6.5778e-04
Epoch 60/300
125/125 [==============================] - 0s 927us/step - loss: 4.7115e-04 - val_lo
ss: 2.3066e-04
Epoch 61/300
125/125 [==============================] - 0s 939us/step - loss: 4.9786e-04 - val_lo
ss: 5.1548e-04
Epoch 62/300
125/125 [==============================] - 0s 920us/step - loss: 3.4572e-04 - val_lo
ss: 2.1132e-04
Epoch 63/300
125/125 [==============================] - 0s 930us/step - loss: 4.7837e-04 - val_lo
ss: 0.0028
Epoch 64/300
125/125 [==============================] - 0s 968us/step - loss: 0.0012 - val_loss:
4.3768e-04
Epoch 65/300
125/125 [==============================] - 0s 919us/step - loss: 3.1221e-04 - val_lo
ss: 2.9563e-04
Epoch 66/300
125/125 [==============================] - 0s 922us/step - loss: 3.5592e-04 - val_lo
ss: 2.1807e-04
Epoch 67/300
125/125 [==============================] - 0s 917us/step - loss: 3.4168e-04 - val_lo
ss: 3.4431e-04
Epoch 68/300
125/125 [==============================] - 0s 921us/step - loss: 5.6394e-04 - val_lo
ss: 2.0743e-04
Epoch 69/300
125/125 [==============================] - 0s 923us/step - loss: 3.7839e-04 - val_lo
ss: 3.8378e-04
Epoch 70/300
125/125 [==============================] - 0s 942us/step - loss: 2.9030e-04 - val_lo
ss: 1.8178e-04
Epoch 71/300
125/125 [==============================] - 0s 928us/step - loss: 4.3168e-04 - val_lo
ss: 0.0045
Epoch 72/300
125/125 [==============================] - 0s 919us/step - loss: 7.1204e-04 - val_lo
ss: 3.3002e-04
Epoch 73/300
125/125 [==============================] - 0s 920us/step - loss: 2.7550e-04 - val_lo
ss: 2.7567e-04
Epoch 74/300
125/125 [==============================] - 0s 920us/step - loss: 7.9673e-04 - val_lo
ss: 3.2205e-04
Epoch 75/300
125/125 [==============================] - 0s 931us/step - loss: 3.6196e-04 - val_lo
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ss: 2.2033e-04
Epoch 76/300
125/125 [==============================] - 0s 919us/step - loss: 3.8470e-04 - val_lo
ss: 2.4852e-04
Epoch 77/300
125/125 [==============================] - 0s 926us/step - loss: 5.5299e-04 - val_lo
ss: 4.6560e-04
Epoch 78/300
125/125 [==============================] - 0s 932us/step - loss: 4.2321e-04 - val_lo
ss: 4.2760e-04
Epoch 79/300
125/125 [==============================] - 0s 921us/step - loss: 4.1099e-04 - val_lo
ss: 9.3792e-04
Epoch 80/300
125/125 [==============================] - 0s 920us/step - loss: 4.2341e-04 - val_lo
ss: 4.3491e-04
Epoch 81/300
125/125 [==============================] - 0s 944us/step - loss: 5.4267e-04 - val_lo
ss: 2.0003e-04
Epoch 82/300
125/125 [==============================] - 0s 914us/step - loss: 7.6509e-04 - val_lo
ss: 2.3197e-04
Epoch 83/300
125/125 [==============================] - 0s 912us/step - loss: 2.9950e-04 - val_lo
ss: 3.5214e-04
Epoch 84/300
125/125 [==============================] - 0s 912us/step - loss: 5.0429e-04 - val_lo
ss: 3.3936e-04
Epoch 85/300
125/125 [==============================] - 0s 912us/step - loss: 4.7839e-04 - val_lo
ss: 4.9366e-04
Epoch 86/300
125/125 [==============================] - 0s 921us/step - loss: 3.3145e-04 - val_lo
ss: 4.2338e-04
Epoch 87/300
125/125 [==============================] - 0s 960us/step - loss: 6.8728e-04 - val_lo
ss: 2.2118e-04
Epoch 88/300
125/125 [==============================] - 0s 924us/step - loss: 5.1166e-04 - val_lo
ss: 4.0625e-04
Epoch 89/300
125/125 [==============================] - 0s 916us/step - loss: 4.1651e-04 - val_lo
ss: 4.0907e-04
Epoch 90/300
125/125 [==============================] - 0s 922us/step - loss: 4.9746e-04 - val_lo
ss: 6.2270e-04
Epoch 91/300
125/125 [==============================] - 0s 921us/step - loss: 4.9852e-04 - val_lo
ss: 3.1046e-04
Epoch 92/300
125/125 [==============================] - 0s 926us/step - loss: 4.8357e-04 - val_lo
ss: 2.7099e-04
Epoch 93/300
125/125 [==============================] - 0s 914us/step - loss: 3.6863e-04 - val_lo
ss: 3.8175e-04
Epoch 94/300
```

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125/125 [==============================] - 0s 920us/step - loss: 3.5613e-04 - val_lo
ss: 7.9996e-04
Epoch 95/300
125/125 [==============================] - 0s 908us/step - loss: 6.2256e-04 - val_lo
ss: 2.8357e-04
Epoch 96/300
125/125 [==============================] - 0s 920us/step - loss: 4.5132e-04 - val_lo
ss: 2.6260e-04
Epoch 97/300
125/125 [==============================] - 0s 937us/step - loss: 5.2480e-04 - val_lo
ss: 6.7679e-04
Epoch 98/300
125/125 [==============================] - 0s 924us/step - loss: 3.9848e-04 - val_lo
ss: 5.2756e-04
Epoch 99/300
125/125 [==============================] - 0s 915us/step - loss: 3.2691e-04 - val_lo
ss: 4.0544e-04
Epoch 100/300
125/125 [==============================] - 0s 912us/step - loss: 4.6219e-04 - val_lo
ss: 2.3085e-04
Epoch 101/300
125/125 [==============================] - 0s 916us/step - loss: 4.4867e-04 - val_lo
ss: 5.7679e-04
Epoch 102/300
125/125 [==============================] - 0s 920us/step - loss: 3.9820e-04 - val_lo
ss: 3.5505e-04
Epoch 103/300
125/125 [==============================] - 0s 920us/step - loss: 4.0739e-04 - val_lo
ss: 2.3477e-04
Epoch 104/300
125/125 [==============================] - 0s 919us/step - loss: 8.7550e-04 - val_lo
ss: 6.5139e-04
Epoch 105/300
125/125 [==============================] - 0s 917us/step - loss: 9.6124e-04 - val_lo
ss: 4.3056e-04
Epoch 106/300
125/125 [==============================] - 0s 920us/step - loss: 3.3866e-04 - val_lo
ss: 5.8766e-04
Epoch 107/300
125/125 [==============================] - 0s 932us/step - loss: 4.5574e-04 - val_lo
ss: 1.9171e-04
Epoch 108/300
125/125 [==============================] - 0s 932us/step - loss: 3.3222e-04 - val_lo
ss: 2.5778e-04
Epoch 109/300
125/125 [==============================] - 0s 928us/step - loss: 3.6795e-04 - val_lo
ss: 5.2843e-04
Epoch 110/300
125/125 [==============================] - 0s 920us/step - loss: 4.3538e-04 - val_lo
ss: 3.5004e-04
Epoch 111/300
125/125 [==============================] - 0s 915us/step - loss: 5.8384e-04 - val_lo
ss: 0.0010
Epoch 112/300
125/125 [==============================] - 0s 935us/step - loss: 3.3701e-04 - val_lo
ss: 2.6675e-04
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Epoch 113/300
125/125 [==============================] - 0s 925us/step - loss: 4.4470e-04 - val_lo
ss: 0.0012
Epoch 114/300
125/125 [==============================] - 0s 931us/step - loss: 4.6220e-04 - val_lo
ss: 5.3969e-04
Epoch 115/300
125/125 [==============================] - 0s 942us/step - loss: 4.1343e-04 - val_lo
ss: 3.0325e-04
Epoch 116/300
125/125 [==============================] - 0s 927us/step - loss: 3.3747e-04 - val_lo
ss: 7.3187e-04
Epoch 117/300
125/125 [==============================] - 0s 925us/step - loss: 4.8740e-04 - val_lo
ss: 2.1476e-04
Epoch 118/300
125/125 [==============================] - 0s 925us/step - loss: 6.1999e-04 - val_lo
ss: 6.8005e-04
Epoch 119/300
125/125 [==============================] - 0s 921us/step - loss: 3.0250e-04 - val_lo
ss: 4.6937e-04
Epoch 120/300
125/125 [==============================] - 0s 924us/step - loss: 3.7369e-04 - val_lo
ss: 3.2968e-04
Epoch 121/300
125/125 [==============================] - 0s 925us/step - loss: 6.4399e-04 - val_lo
ss: 0.0011
Epoch 122/300
125/125 [==============================] - 0s 920us/step - loss: 4.3002e-04 - val_lo
ss: 2.5285e-04
Epoch 123/300
125/125 [==============================] - 0s 924us/step - loss: 2.8234e-04 - val_lo
ss: 2.3238e-04
Epoch 124/300
125/125 [==============================] - 0s 924us/step - loss: 4.4472e-04 - val_lo
ss: 7.5039e-04
Epoch 125/300
125/125 [==============================] - 0s 918us/step - loss: 5.2342e-04 - val_lo
ss: 7.2906e-04
Epoch 126/300
125/125 [==============================] - 0s 928us/step - loss: 4.5975e-04 - val_lo
ss: 1.8414e-04
Epoch 127/300
125/125 [==============================] - 0s 923us/step - loss: 4.5061e-04 - val_lo
ss: 3.7566e-04
Epoch 128/300
125/125 [==============================] - 0s 920us/step - loss: 5.3233e-04 - val_lo
ss: 4.8864e-04
Epoch 129/300
125/125 [==============================] - 0s 924us/step - loss: 6.0074e-04 - val_lo
ss: 2.5620e-04
Epoch 130/300
125/125 [==============================] - 0s 917us/step - loss: 3.3203e-04 - val_lo
ss: 2.1311e-04
Epoch 131/300
125/125 [==============================] - 0s 917us/step - loss: 3.7270e-04 - val_lo
```

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ss: 4.2913e-04
Epoch 132/300
125/125 [==============================] - 0s 927us/step - loss: 4.7248e-04 - val_lo
ss: 2.5499e-04
Epoch 133/300
125/125 [==============================] - 0s 920us/step - loss: 3.5076e-04 - val_lo
ss: 3.7360e-04
Epoch 134/300
125/125 [==============================] - 0s 913us/step - loss: 5.0687e-04 - val_lo
ss: 0.0034
Epoch 135/300
125/125 [==============================] - 0s 916us/step - loss: 9.3195e-04 - val_lo
ss: 8.5245e-04
Epoch 136/300
125/125 [==============================] - 0s 917us/step - loss: 4.0977e-04 - val_lo
ss: 7.4251e-04
Epoch 137/300
125/125 [==============================] - 0s 948us/step - loss: 3.1741e-04 - val_lo
ss: 2.9799e-04
Epoch 138/300
125/125 [==============================] - 0s 916us/step - loss: 6.8679e-04 - val_lo
ss: 2.6942e-04
Epoch 139/300
125/125 [==============================] - 0s 912us/step - loss: 3.8208e-04 - val_lo
ss: 2.9634e-04
Epoch 140/300
125/125 [==============================] - 0s 926us/step - loss: 3.5662e-04 - val_lo
ss: 2.1828e-04
Epoch 141/300
125/125 [==============================] - 0s 920us/step - loss: 3.4976e-04 - val_lo
ss: 4.2096e-04
Epoch 142/300
125/125 [==============================] - 0s 924us/step - loss: 4.3678e-04 - val_lo
ss: 3.8806e-04
Epoch 143/300
125/125 [==============================] - 0s 920us/step - loss: 3.5404e-04 - val_lo
ss: 2.5108e-04
Epoch 144/300
125/125 [==============================] - 0s 926us/step - loss: 3.3893e-04 - val_lo
ss: 5.5803e-04
Epoch 145/300
125/125 [==============================] - 0s 926us/step - loss: 3.5836e-04 - val_lo
ss: 1.9914e-04
Epoch 146/300
125/125 [==============================] - 0s 915us/step - loss: 2.8930e-04 - val_lo
ss: 2.5264e-04
Epoch 147/300
125/125 [==============================] - 0s 927us/step - loss: 4.6098e-04 - val_lo
ss: 4.4443e-04
Epoch 148/300
125/125 [==============================] - 0s 916us/step - loss: 3.6848e-04 - val_lo
ss: 3.8862e-04
Epoch 149/300
125/125 [==============================] - 0s 969us/step - loss: 3.7491e-04 - val_lo
ss: 3.2726e-04
Epoch 150/300
```

```
125/125 [==============================] - 0s 925us/step - loss: 3.3250e-04 - val_lo
ss: 4.4276e-04
Epoch 151/300
125/125 [==============================] - 0s 940us/step - loss: 7.2591e-04 - val_lo
ss: 4.0987e-04
Epoch 152/300
125/125 [==============================] - 0s 928us/step - loss: 3.4509e-04 - val_lo
ss: 3.3218e-04
Epoch 153/300
125/125 [==============================] - 0s 924us/step - loss: 3.7529e-04 - val_lo
ss: 5.9893e-04
Epoch 154/300
125/125 [==============================] - 0s 924us/step - loss: 4.2360e-04 - val_lo
ss: 3.6592e-04
Epoch 155/300
125/125 [==============================] - 0s 932us/step - loss: 3.9371e-04 - val_lo
ss: 2.5401e-04
Epoch 156/300
125/125 [==============================] - 0s 922us/step - loss: 2.9410e-04 - val_lo
ss: 4.0790e-04
Epoch 157/300
125/125 [==============================] - 0s 924us/step - loss: 5.3791e-04 - val_lo
ss: 4.6107e-04
Epoch 158/300
125/125 [==============================] - 0s 932us/step - loss: 3.3379e-04 - val_lo
ss: 2.7759e-04
Epoch 159/300
125/125 [==============================] - 0s 924us/step - loss: 3.2696e-04 - val_lo
ss: 4.1654e-04
Epoch 160/300
125/125 [==============================] - 0s 932us/step - loss: 0.0011 - val_loss:
3.2780e-04
Epoch 161/300
125/125 [==============================] - 0s 945us/step - loss: 3.9534e-04 - val_lo
ss: 2.8061e-04
Epoch 162/300
125/125 [==============================] - 0s 926us/step - loss: 3.9228e-04 - val_lo
ss: 2.0388e-04
Epoch 163/300
125/125 [==============================] - 0s 927us/step - loss: 3.1008e-04 - val_lo
ss: 3.4503e-04
Epoch 164/300
125/125 [==============================] - 0s 926us/step - loss: 4.0656e-04 - val_lo
ss: 2.0606e-04
Epoch 165/300
125/125 [==============================] - 0s 944us/step - loss: 3.2804e-04 - val_lo
ss: 3.6965e-04
Epoch 166/300
125/125 [==============================] - 0s 961us/step - loss: 4.8669e-04 - val_lo
ss: 4.2515e-04
Epoch 167/300
125/125 [==============================] - 0s 933us/step - loss: 3.5272e-04 - val_lo
ss: 2.0713e-04
Epoch 168/300
125/125 [==============================] - 0s 930us/step - loss: 3.1780e-04 - val_lo
ss: 3.1398e-04
```

```
Epoch 169/300
125/125 [==============================] - 0s 923us/step - loss: 3.0407e-04 - val_lo
ss: 3.8013e-04
Epoch 170/300
125/125 [==============================] - 0s 930us/step - loss: 4.1455e-04 - val_lo
ss: 2.0581e-04
Epoch 171/300
125/125 [==============================] - 0s 932us/step - loss: 3.6383e-04 - val_lo
ss: 3.4173e-04
Epoch 172/300
125/125 [==============================] - 0s 937us/step - loss: 8.7646e-04 - val_lo
ss: 4.7830e-04
Epoch 173/300
125/125 [==============================] - 0s 925us/step - loss: 3.8456e-04 - val_lo
ss: 2.1215e-04
Epoch 174/300
125/125 [==============================] - 0s 931us/step - loss: 2.8109e-04 - val_lo
ss: 3.4084e-04
Epoch 175/300
125/125 [==============================] - 0s 928us/step - loss: 3.6229e-04 - val_lo
ss: 2.1494e-04
Epoch 176/300
125/125 [==============================] - 0s 924us/step - loss: 4.0414e-04 - val_lo
ss: 2.3164e-04
Epoch 177/300
125/125 [==============================] - 0s 920us/step - loss: 4.8161e-04 - val_lo
ss: 3.6401e-04
Epoch 178/300
125/125 [==============================] - 0s 924us/step - loss: 2.7751e-04 - val_lo
ss: 4.3501e-04
Epoch 179/300
125/125 [==============================] - 0s 940us/step - loss: 4.2594e-04 - val_lo
ss: 4.9910e-04
Epoch 180/300
125/125 [==============================] - 0s 931us/step - loss: 4.1419e-04 - val_lo
ss: 2.7546e-04
Epoch 181/300
125/125 [==============================] - 0s 925us/step - loss: 5.2288e-04 - val_lo
ss: 4.5182e-04
Epoch 182/300
125/125 [==============================] - 0s 944us/step - loss: 4.0986e-04 - val_lo
ss: 2.4665e-04
Epoch 183/300
125/125 [==============================] - 0s 937us/step - loss: 3.0135e-04 - val_lo
ss: 2.8320e-04
Epoch 184/300
125/125 [==============================] - 0s 975us/step - loss: 5.1990e-04 - val_lo
ss: 2.9964e-04
Epoch 185/300
125/125 [==============================] - 0s 929us/step - loss: 3.3798e-04 - val_lo
ss: 2.5144e-04
Epoch 186/300
125/125 [==============================] - 0s 931us/step - loss: 2.9243e-04 - val_lo
ss: 5.7161e-04
Epoch 187/300
125/125 [==============================] - 0s 928us/step - loss: 4.9957e-04 - val_lo
```

```
ss: 2.8942e-04
Epoch 188/300
125/125 [==============================] - 0s 928us/step - loss: 4.0371e-04 - val_lo
ss: 3.6266e-04
Epoch 189/300
125/125 [==============================] - 0s 930us/step - loss: 3.9161e-04 - val_lo
ss: 2.7974e-04
Epoch 190/300
125/125 [==============================] - 0s 917us/step - loss: 4.3759e-04 - val_lo
ss: 2.7604e-04
Epoch 191/300
125/125 [==============================] - 0s 958us/step - loss: 3.3626e-04 - val_lo
ss: 4.1050e-04
Epoch 192/300
125/125 [==============================] - 0s 940us/step - loss: 3.0457e-04 - val_lo
ss: 4.8691e-04
Epoch 193/300
125/125 [==============================] - 0s 943us/step - loss: 5.2014e-04 - val_lo
ss: 7.6109e-04
Epoch 194/300
125/125 [==============================] - 0s 918us/step - loss: 3.5152e-04 - val_lo
ss: 2.6623e-04
Epoch 195/300
125/125 [==============================] - 0s 923us/step - loss: 3.2915e-04 - val_lo
ss: 3.0914e-04
Epoch 196/300
125/125 [==============================] - 0s 933us/step - loss: 3.8700e-04 - val_lo
ss: 3.5438e-04
Epoch 197/300
125/125 [==============================] - 0s 928us/step - loss: 4.0167e-04 - val_lo
ss: 2.1850e-04
Epoch 198/300
125/125 [==============================] - 0s 927us/step - loss: 3.9818e-04 - val_lo
ss: 5.8242e-04
Epoch 199/300
125/125 [==============================] - 0s 964us/step - loss: 4.8648e-04 - val_lo
ss: 2.7462e-04
Epoch 200/300
125/125 [==============================] - 0s 944us/step - loss: 2.9885e-04 - val_lo
ss: 3.2626e-04
Epoch 201/300
125/125 [==============================] - 0s 1ms/step - loss: 4.4792e-04 - val_los
s: 4.9040e-04
Epoch 202/300
125/125 [==============================] - 0s 960us/step - loss: 3.4393e-04 - val_lo
ss: 3.9322e-04
Epoch 203/300
125/125 [==============================] - 0s 934us/step - loss: 3.6070e-04 - val_lo
ss: 2.4644e-04
Epoch 204/300
125/125 [==============================] - 0s 927us/step - loss: 5.4421e-04 - val_lo
ss: 2.2411e-04
Epoch 205/300
125/125 [==============================] - 0s 923us/step - loss: 3.9033e-04 - val_lo
ss: 4.8670e-04
Epoch 206/300
```

```
125/125 [==============================] - 0s 928us/step - loss: 3.6140e-04 - val_lo
ss: 2.8518e-04
Epoch 207/300
125/125 [==============================] - 0s 940us/step - loss: 3.0173e-04 - val_lo
ss: 4.0946e-04
Epoch 208/300
125/125 [==============================] - 0s 947us/step - loss: 2.8402e-04 - val_lo
ss: 2.8293e-04
Epoch 209/300
125/125 [==============================] - 0s 931us/step - loss: 3.6469e-04 - val_lo
ss: 4.2455e-04
Epoch 210/300
125/125 [==============================] - 0s 936us/step - loss: 3.5546e-04 - val_lo
ss: 2.2053e-04
Epoch 211/300
125/125 [==============================] - 0s 934us/step - loss: 4.2941e-04 - val_lo
ss: 7.4603e-04
Epoch 212/300
125/125 [==============================] - 0s 929us/step - loss: 4.2992e-04 - val_lo
ss: 7.4813e-04
Epoch 213/300
125/125 [==============================] - 0s 928us/step - loss: 6.4267e-04 - val_lo
ss: 2.4832e-04
Epoch 214/300
125/125 [==============================] - 0s 934us/step - loss: 3.6261e-04 - val_lo
ss: 4.3882e-04
Epoch 215/300
125/125 [==============================] - 0s 929us/step - loss: 3.6730e-04 - val_lo
ss: 2.7622e-04
Epoch 216/300
125/125 [==============================] - 0s 931us/step - loss: 3.4863e-04 - val_lo
ss: 2.5697e-04
Epoch 217/300
125/125 [==============================] - 0s 939us/step - loss: 3.3417e-04 - val_lo
ss: 3.4096e-04
Epoch 218/300
125/125 [==============================] - 0s 923us/step - loss: 3.9844e-04 - val_lo
ss: 2.4670e-04
Epoch 219/300
125/125 [==============================] - 0s 996us/step - loss: 6.6532e-04 - val_lo
ss: 6.7591e-04
Epoch 220/300
125/125 [==============================] - 0s 948us/step - loss: 3.2272e-04 - val_lo
ss: 2.5022e-04
Epoch 221/300
125/125 [==============================] - 0s 980us/step - loss: 3.1269e-04 - val_lo
ss: 3.8926e-04
Epoch 222/300
125/125 [==============================] - 0s 942us/step - loss: 4.1312e-04 - val_lo
ss: 4.3060e-04
Epoch 223/300
125/125 [==============================] - 0s 932us/step - loss: 3.7294e-04 - val_lo
ss: 1.8779e-04
Epoch 224/300
125/125 [==============================] - 0s 940us/step - loss: 4.3829e-04 - val_lo
ss: 4.8510e-04
```

```
Epoch 225/300
125/125 [==============================] - 0s 948us/step - loss: 5.1129e-04 - val_lo
ss: 8.2755e-04
Epoch 226/300
125/125 [==============================] - 0s 940us/step - loss: 4.8794e-04 - val_lo
ss: 2.0946e-04
Epoch 227/300
125/125 [==============================] - 0s 980us/step - loss: 3.2616e-04 - val_lo
ss: 2.5861e-04
Epoch 228/300
125/125 [==============================] - 0s 968us/step - loss: 2.8643e-04 - val_lo
ss: 2.9617e-04
Epoch 229/300
125/125 [==============================] - 0s 936us/step - loss: 3.4393e-04 - val_lo
ss: 1.9993e-04
Epoch 230/300
125/125 [==============================] - 0s 950us/step - loss: 3.2343e-04 - val_lo
ss: 2.8516e-04
Epoch 231/300
125/125 [==============================] - 0s 936us/step - loss: 4.5917e-04 - val_lo
ss: 0.0013
Epoch 232/300
125/125 [==============================] - 0s 940us/step - loss: 5.0405e-04 - val_lo
ss: 2.9388e-04
Epoch 233/300
125/125 [==============================] - 0s 932us/step - loss: 3.6309e-04 - val_lo
ss: 2.5039e-04
Epoch 234/300
125/125 [==============================] - 0s 940us/step - loss: 3.2615e-04 - val_lo
ss: 2.4219e-04
Epoch 235/300
125/125 [==============================] - 0s 936us/step - loss: 3.1454e-04 - val_lo
ss: 1.8264e-04
Epoch 236/300
125/125 [==============================] - 0s 930us/step - loss: 3.2630e-04 - val_lo
ss: 2.6753e-04
Epoch 237/300
125/125 [==============================] - 0s 948us/step - loss: 3.1300e-04 - val_lo
ss: 4.5329e-04
Epoch 238/300
125/125 [==============================] - 0s 984us/step - loss: 4.9961e-04 - val_lo
ss: 3.9686e-04
Epoch 239/300
125/125 [==============================] - 0s 928us/step - loss: 7.3815e-04 - val_lo
ss: 6.1341e-04
Epoch 240/300
125/125 [==============================] - 0s 932us/step - loss: 3.4282e-04 - val_lo
ss: 2.6280e-04
Epoch 241/300
125/125 [==============================] - 0s 960us/step - loss: 3.7243e-04 - val_lo
ss: 3.5609e-04
Epoch 242/300
125/125 [==============================] - 0s 984us/step - loss: 3.1115e-04 - val_lo
ss: 3.3690e-04
Epoch 243/300
125/125 [==============================] - 0s 952us/step - loss: 2.9658e-04 - val_lo
```

```
ss: 3.5740e-04
Epoch 244/300
125/125 [==============================] - 0s 932us/step - loss: 3.3576e-04 - val_lo
ss: 1.8718e-04
Epoch 245/300
125/125 [==============================] - 0s 928us/step - loss: 3.7997e-04 - val_lo
ss: 2.4812e-04
Epoch 246/300
125/125 [==============================] - 0s 926us/step - loss: 3.5114e-04 - val_lo
ss: 2.4280e-04
Epoch 247/300
125/125 [==============================] - 0s 916us/step - loss: 3.5738e-04 - val_lo
ss: 2.2795e-04
Epoch 248/300
125/125 [==============================] - 0s 924us/step - loss: 5.1795e-04 - val_lo
ss: 5.2819e-04
Epoch 249/300
125/125 [==============================] - 0s 934us/step - loss: 4.5756e-04 - val_lo
ss: 3.3930e-04
Epoch 250/300
125/125 [==============================] - 0s 952us/step - loss: 3.3510e-04 - val_lo
ss: 2.2815e-04
Epoch 251/300
125/125 [==============================] - 0s 952us/step - loss: 3.2178e-04 - val_lo
ss: 2.9354e-04
Epoch 252/300
125/125 [==============================] - 0s 948us/step - loss: 2.9556e-04 - val_lo
ss: 2.5125e-04
Epoch 253/300
125/125 [==============================] - 0s 924us/step - loss: 3.4507e-04 - val_lo
ss: 4.9274e-04
Epoch 254/300
125/125 [==============================] - 0s 936us/step - loss: 3.1440e-04 - val_lo
ss: 1.9689e-04
Epoch 255/300
125/125 [==============================] - 0s 936us/step - loss: 2.5203e-04 - val_lo
ss: 4.7815e-04
Epoch 256/300
125/125 [==============================] - 0s 940us/step - loss: 3.6050e-04 - val_lo
ss: 2.1606e-04
Epoch 257/300
125/125 [==============================] - 0s 927us/step - loss: 5.7991e-04 - val_lo
ss: 3.6534e-04
Epoch 258/300
125/125 [==============================] - 0s 940us/step - loss: 3.5936e-04 - val_lo
ss: 2.3017e-04
Epoch 259/300
125/125 [==============================] - 0s 1ms/step - loss: 3.1480e-04 - val_los
s: 3.3468e-04
Epoch 260/300
125/125 [==============================] - 0s 932us/step - loss: 4.6192e-04 - val_lo
ss: 2.9721e-04
Epoch 261/300
125/125 [==============================] - 0s 968us/step - loss: 3.1543e-04 - val_lo
ss: 2.2484e-04
Epoch 262/300
```

```
125/125 [==============================] - 0s 952us/step - loss: 3.9772e-04 - val_lo
ss: 5.3690e-04
Epoch 263/300
125/125 [==============================] - 0s 956us/step - loss: 3.8051e-04 - val_lo
ss: 6.0077e-04
Epoch 264/300
125/125 [==============================] - 0s 947us/step - loss: 8.4202e-04 - val_lo
ss: 0.0023
Epoch 265/300
125/125 [==============================] - 0s 940us/step - loss: 3.8045e-04 - val_lo
ss: 4.2577e-04
Epoch 266/300
125/125 [==============================] - 0s 944us/step - loss: 3.4819e-04 - val_lo
ss: 2.4248e-04
Epoch 267/300
125/125 [==============================] - 0s 952us/step - loss: 4.4136e-04 - val_lo
ss: 3.0695e-04
Epoch 268/300
125/125 [==============================] - 0s 924us/step - loss: 2.6391e-04 - val_lo
ss: 3.2753e-04
Epoch 269/300
125/125 [==============================] - 0s 932us/step - loss: 3.8992e-04 - val_lo
ss: 3.6922e-04
Epoch 270/300
125/125 [==============================] - 0s 955us/step - loss: 2.8635e-04 - val_lo
ss: 2.4000e-04
Epoch 271/300
125/125 [==============================] - 0s 936us/step - loss: 3.5708e-04 - val_lo
ss: 2.9462e-04
Epoch 272/300
125/125 [==============================] - 0s 949us/step - loss: 4.0187e-04 - val_lo
ss: 2.3128e-04
Epoch 273/300
125/125 [==============================] - 0s 932us/step - loss: 2.9510e-04 - val_lo
ss: 2.0473e-04
Epoch 274/300
125/125 [==============================] - 0s 932us/step - loss: 2.8172e-04 - val_lo
ss: 2.4051e-04
Epoch 275/300
125/125 [==============================] - 0s 952us/step - loss: 3.1335e-04 - val_lo
ss: 5.8070e-04
Epoch 276/300
125/125 [==============================] - 0s 936us/step - loss: 3.9634e-04 - val_lo
ss: 3.7938e-04
Epoch 277/300
125/125 [==============================] - 0s 931us/step - loss: 4.1560e-04 - val_lo
ss: 3.1214e-04
Epoch 278/300
125/125 [==============================] - 0s 940us/step - loss: 4.0510e-04 - val_lo
ss: 5.9967e-04
Epoch 279/300
125/125 [==============================] - 0s 968us/step - loss: 2.9614e-04 - val_lo
ss: 1.9951e-04
Epoch 280/300
125/125 [==============================] - 0s 943us/step - loss: 4.0913e-04 - val_lo
ss: 2.9964e-04
```

```
Epoch 281/300
125/125 [==============================] - 0s 952us/step - loss: 4.0667e-04 - val_lo
ss: 5.4941e-04
Epoch 282/300
125/125 [==============================] - 0s 939us/step - loss: 4.8332e-04 - val_lo
ss: 5.3297e-04
Epoch 283/300
125/125 [==============================] - 0s 929us/step - loss: 4.1213e-04 - val_lo
ss: 3.3563e-04
Epoch 284/300
125/125 [==============================] - 0s 935us/step - loss: 3.3191e-04 - val_lo
ss: 2.9016e-04
Epoch 285/300
125/125 [==============================] - 0s 927us/step - loss: 4.1438e-04 - val_lo
ss: 1.8703e-04
Epoch 286/300
125/125 [==============================] - 0s 928us/step - loss: 3.1806e-04 - val_lo
ss: 2.4718e-04
Epoch 287/300
125/125 [==============================] - 0s 932us/step - loss: 3.2867e-04 - val_lo
ss: 2.1201e-04
Epoch 288/300
125/125 [==============================] - 0s 920us/step - loss: 3.4735e-04 - val_lo
ss: 2.5036e-04
Epoch 289/300
125/125 [==============================] - 0s 923us/step - loss: 3.8168e-04 - val_lo
ss: 7.0423e-04
Epoch 290/300
125/125 [==============================] - 0s 923us/step - loss: 3.3454e-04 - val_lo
ss: 3.8124e-04
Epoch 291/300
125/125 [==============================] - 0s 926us/step - loss: 3.5696e-04 - val_lo
ss: 3.3972e-04
Epoch 292/300
125/125 [==============================] - 0s 928us/step - loss: 3.6741e-04 - val_lo
ss: 4.3617e-04
Epoch 293/300
125/125 [==============================] - 0s 924us/step - loss: 4.9260e-04 - val_lo
ss: 2.0218e-04
Epoch 294/300
125/125 [==============================] - 0s 926us/step - loss: 3.9859e-04 - val_lo
ss: 6.0164e-04
Epoch 295/300
125/125 [==============================] - 0s 928us/step - loss: 3.4082e-04 - val_lo
ss: 6.9189e-04
Epoch 296/300
125/125 [==============================] - 0s 936us/step - loss: 3.1805e-04 - val_lo
ss: 3.6729e-04
Epoch 297/300
125/125 [==============================] - 0s 992us/step - loss: 2.8800e-04 - val_lo
ss: 2.5479e-04
Epoch 298/300
125/125 [==============================] - 0s 922us/step - loss: 5.1041e-04 - val_lo
ss: 8.6920e-04
Epoch 299/300
125/125 [==============================] - 0s 928us/step - loss: 4.1581e-04 - val_lo
```

```
ss: 2.9996e-04
Epoch 300/300
125/125 [==============================] - 0s 924us/step - loss: 4.1494e-04 - val_lo
ss: 3.8418e-04
```

In [ ]:

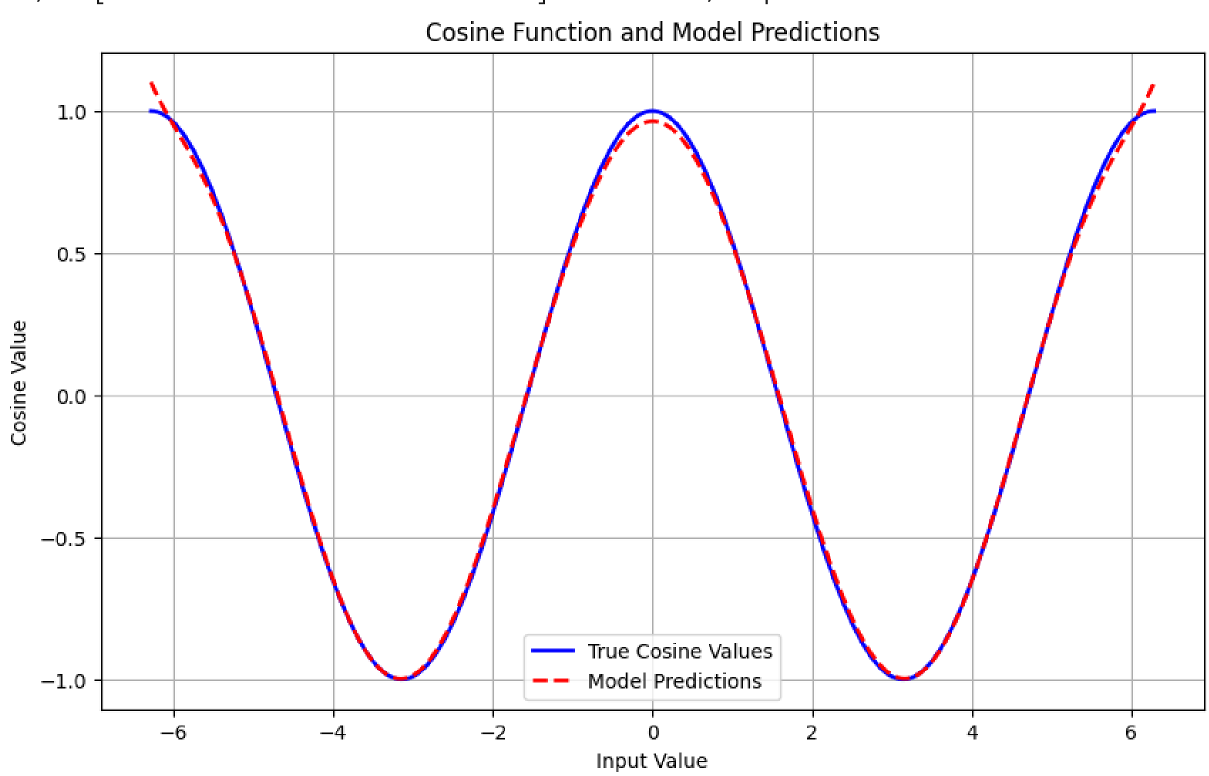
```
val_loss = model.evaluate(X_val, y_val, verbose=0)
print(f"Validation loss: {val_loss}")

import matplotlib.pyplot as plt

num_test_samples = 1000
X_test = np.linspace(lower_bound, upper_bound, num=num_test_samples).reshape(-1, 1)
y_true = np.cos(X_test)
y_pred = model.predict(X_test)

plt.figure(figsize=(10, 6))
plt.plot(X_test, y_true, label='True Cosine Values', color='b', linewidth=2)
plt.plot(X_test, y_pred, label='Model Predictions', color='r', linestyle='--', line
plt.xlabel('Input Value')
plt.ylabel('Cosine Value')
plt.title('Cosine Function and Model Predictions')
plt.legend()
plt.grid()
plt.show()
```

```
Validation loss: 0.00038418357144109905
32/32 [==============================] - 0s 515us/step
```



Validation loss: 0.00038

LAYER MODE

In [ ]:
```
import tensorflow as tf
from tensorflow.keras.layers import Input, Add, Dense, Layer
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam

class H1Layer(Layer):
    def __init__(self, **kwargs):
        super(H1Layer, self).__init__(**kwargs)

    def build(self, input_shape):
        self.b = self.add_weight(shape=(input_shape[-1],),
                                 initializer='random_normal',
                                 trainable=True)
        super(H1Layer, self).build(input_shape)

    def call(self, x):
        return self.b * (2 * x)
        #return (2 * x)


class H2Layer(Layer):
    def __init__(self, h1, **kwargs):
        super(H2Layer, self).__init__(**kwargs)
        self.h1 = h1

    def call(self, x):
        return (2*x*(self.h1(x)))-2

class H3Layer(Layer):
    def __init__(self, h2, **kwargs):
        super(H3Layer, self).__init__(**kwargs)
        self.h2 = h2

    def call(self, x):
        return (2*x*(self.h2(x)))-(4*self.h2(x))

class H4Layer(Layer):
    def __init__(self, h3, **kwargs):
        super(H4Layer, self).__init__(**kwargs)
        self.h3 = h3

    def call(self, x):
        return (2*x*(self.h3(x)))-(6*self.h3(x))

def build_model(input_shape, filters):
    input_layer = Input(shape=input_shape)
    x = input_layer

    h1 = H1Layer()
    h2 = H2Layer(h1)
    h3 = H3Layer(h2)
```

```
    h4 = H4Layer(h3)
    x = Dense(filters)(x)
    x = h2(x)
    x = Dense(filters)(x)
    x = h3(x)
    x = Dense(filters)(x)
    x = h4(x)
    x = Dense(filters)(x)

    output_layer = Dense(1)(x)
    model = Model(inputs=input_layer, outputs=output_layer)

    return model


input_shape = (1,)
filters = 16
model = build_model(input_shape, filters)
optimizer = Adam(learning_rate=0.00001) # Reduce learning rate
model.compile(optimizer='adam', loss='mse')
```

- n = 4
- Values does not explode since it is just one layer of each, On resnet it repeats the number of blocks
- Has to be trained arround 600 epochs to get proper results

In [ ]:
```
import numpy as np

np.random.seed(42)
n_samples = 10000
lower_bound = -2 * np.pi
upper_bound = 2 * np.pi
#lower_bound = -10
#upper_bound = 10

X = np.random.uniform(lower_bound, upper_bound, size=(n_samples, 1))
y = np.cos(X)

from sklearn.model_selection import train_test_split

X_train, X_val, y_train, y_val = train_test_split(X, y, test_size=0.2, random_state

batch_size = 64
epochs = 600

history = model.fit(X_train, y_train,
                    batch_size=batch_size,
                    epochs=epochs,
                    verbose=1,
                    validation_data=(X_val, y_val))
```

```
Epoch 1/600
125/125 [==============================] - 1s 2ms/step - loss: 5901223936.0000 - val
_loss: 1276851.8750
Epoch 2/600
125/125 [==============================] - 0s 968us/step - loss: 1099936.5000 - val_
loss: 1019170.6875
Epoch 3/600
125/125 [==============================] - 0s 956us/step - loss: 898679.0625 - val_l
oss: 817324.3750
Epoch 4/600
125/125 [==============================] - 0s 1ms/step - loss: 716052.5000 - val_los
s: 647281.8125
Epoch 5/600
125/125 [==============================] - 0s 987us/step - loss: 567502.9375 - val_l
oss: 518242.2500
Epoch 6/600
125/125 [==============================] - 0s 961us/step - loss: 456433.5625 - val_l
oss: 422671.1250
Epoch 7/600
125/125 [==============================] - 0s 960us/step - loss: 379380.5312 - val_l
oss: 361106.1250
Epoch 8/600
125/125 [==============================] - 0s 960us/step - loss: 327619.4688 - val_l
oss: 319342.0938
Epoch 9/600
125/125 [==============================] - 0s 948us/step - loss: 293943.4375 - val_l
oss: 292208.1562
Epoch 10/600
125/125 [==============================] - 0s 988us/step - loss: 270918.2500 - val_l
oss: 273723.7812
Epoch 11/600
125/125 [==============================] - 0s 984us/step - loss: 254689.4844 - val_l
oss: 257008.8125
Epoch 12/600
125/125 [==============================] - 0s 946us/step - loss: 240981.4062 - val_l
oss: 245400.6406
Epoch 13/600
125/125 [==============================] - 0s 944us/step - loss: 229535.6094 - val_l
oss: 233437.2031
Epoch 14/600
125/125 [==============================] - 0s 956us/step - loss: 219309.0312 - val_l
oss: 223296.2500
Epoch 15/600
125/125 [==============================] - 0s 964us/step - loss: 210060.3125 - val_l
oss: 213733.6250
Epoch 16/600
125/125 [==============================] - 0s 957us/step - loss: 201625.0469 - val_l
oss: 205211.1406
Epoch 17/600
125/125 [==============================] - 0s 944us/step - loss: 192952.5781 - val_l
oss: 196651.4062
Epoch 18/600
125/125 [==============================] - 0s 952us/step - loss: 184810.7500 - val_l
oss: 188842.0781
Epoch 19/600
125/125 [==============================] - 0s 951us/step - loss: 178212.7812 - val_l
```

```
oss: 182335.1406
Epoch 20/600
125/125 [==============================] - 0s 952us/step - loss: 170455.4375 - val_l
oss: 173950.9844
Epoch 21/600
125/125 [==============================] - 0s 947us/step - loss: 164229.9375 - val_l
oss: 166765.8906
Epoch 22/600
125/125 [==============================] - 0s 951us/step - loss: 157431.9531 - val_l
oss: 160311.4844
Epoch 23/600
125/125 [==============================] - 0s 951us/step - loss: 150454.1562 - val_l
oss: 153316.2031
Epoch 24/600
125/125 [==============================] - 0s 941us/step - loss: 144798.8906 - val_l
oss: 148960.6719
Epoch 25/600
125/125 [==============================] - 0s 949us/step - loss: 137763.3906 - val_l
oss: 140235.5938
Epoch 26/600
125/125 [==============================] - 0s 946us/step - loss: 131929.3125 - val_l
oss: 133998.7812
Epoch 27/600
125/125 [==============================] - 0s 952us/step - loss: 126210.0547 - val_l
oss: 129615.2031
Epoch 28/600
125/125 [==============================] - 0s 968us/step - loss: 119910.7656 - val_l
oss: 120997.3984
Epoch 29/600
125/125 [==============================] - 0s 948us/step - loss: 114530.9453 - val_l
oss: 115027.4062
Epoch 30/600
125/125 [==============================] - 0s 944us/step - loss: 107746.7188 - val_l
oss: 109245.3984
Epoch 31/600
125/125 [==============================] - 0s 946us/step - loss: 101723.1250 - val_l
oss: 102967.5312
Epoch 32/600
125/125 [==============================] - 0s 940us/step - loss: 96234.7500 - val_lo
ss: 96522.3438
Epoch 33/600
125/125 [==============================] - 0s 944us/step - loss: 89888.0312 - val_lo
ss: 90743.1250
Epoch 34/600
125/125 [==============================] - 0s 928us/step - loss: 83779.8594 - val_lo
ss: 84302.1094
Epoch 35/600
125/125 [==============================] - 0s 943us/step - loss: 78224.4844 - val_lo
ss: 80464.9062
Epoch 36/600
125/125 [==============================] - 0s 957us/step - loss: 71668.3125 - val_lo
ss: 74693.6484
Epoch 37/600
125/125 [==============================] - 0s 944us/step - loss: 65413.3086 - val_lo
ss: 63487.3164
Epoch 38/600
```

```
125/125 [==============================] - 0s 936us/step - loss: 57738.2969 - val_lo
ss: 56038.9805
Epoch 39/600
125/125 [==============================] - 0s 946us/step - loss: 51413.4688 - val_lo
ss: 49487.6641
Epoch 40/600
125/125 [==============================] - 0s 936us/step - loss: 42627.1445 - val_lo
ss: 40003.6094
Epoch 41/600
125/125 [==============================] - 0s 957us/step - loss: 34846.6133 - val_lo
ss: 31368.6914
Epoch 42/600
125/125 [==============================] - 0s 946us/step - loss: 27690.6309 - val_lo
ss: 24278.6602
Epoch 43/600
125/125 [==============================] - 0s 946us/step - loss: 20014.4668 - val_lo
ss: 17738.2285
Epoch 44/600
125/125 [==============================] - 0s 944us/step - loss: 14636.4561 - val_lo
ss: 12378.9316
Epoch 45/600
125/125 [==============================] - 0s 944us/step - loss: 10392.2451 - val_lo
ss: 8257.5117
Epoch 46/600
125/125 [==============================] - 0s 964us/step - loss: 6802.6318 - val_los
s: 5710.0649
Epoch 47/600
125/125 [==============================] - 0s 960us/step - loss: 4546.8564 - val_los
s: 4122.0020
Epoch 48/600
125/125 [==============================] - 0s 960us/step - loss: 2951.3416 - val_los
s: 2332.8792
Epoch 49/600
125/125 [==============================] - 0s 944us/step - loss: 2040.0432 - val_los
s: 1673.3623
Epoch 50/600
125/125 [==============================] - 0s 952us/step - loss: 1580.1431 - val_los
s: 1547.1133
Epoch 51/600
125/125 [==============================] - 0s 932us/step - loss: 1334.1833 - val_los
s: 1971.7130
Epoch 52/600
125/125 [==============================] - 0s 936us/step - loss: 1115.6788 - val_los
s: 1111.4652
Epoch 53/600
125/125 [==============================] - 0s 940us/step - loss: 1097.3867 - val_los
s: 915.5558
Epoch 54/600
125/125 [==============================] - 0s 932us/step - loss: 1206.2803 - val_los
s: 1160.9067
Epoch 55/600
125/125 [==============================] - 0s 944us/step - loss: 953.8453 - val_los
s: 811.4371
Epoch 56/600
125/125 [==============================] - 0s 936us/step - loss: 888.8054 - val_los
s: 1505.0990
```

```
Epoch 57/600
125/125 [==============================] - 0s 952us/step - loss: 972.7294 - val_los
s: 761.6125
Epoch 58/600
125/125 [==============================] - 0s 953us/step - loss: 808.7408 - val_los
s: 831.0743
Epoch 59/600
125/125 [==============================] - 0s 944us/step - loss: 723.9183 - val_los
s: 736.5197
Epoch 60/600
125/125 [==============================] - 0s 948us/step - loss: 790.0302 - val_los
s: 722.0576
Epoch 61/600
125/125 [==============================] - 0s 940us/step - loss: 842.6805 - val_los
s: 629.0802
Epoch 62/600
125/125 [==============================] - 0s 941us/step - loss: 718.9523 - val_los
s: 748.1063
Epoch 63/600
125/125 [==============================] - 0s 942us/step - loss: 842.2767 - val_los
s: 1000.4028
Epoch 64/600
125/125 [==============================] - 0s 944us/step - loss: 684.0009 - val_los
s: 561.8860
Epoch 65/600
125/125 [==============================] - 0s 942us/step - loss: 634.3323 - val_los
s: 800.6354
Epoch 66/600
125/125 [==============================] - 0s 944us/step - loss: 739.7374 - val_los
s: 1174.6930
Epoch 67/600
125/125 [==============================] - 0s 940us/step - loss: 710.4489 - val_los
s: 1074.1169
Epoch 68/600
125/125 [==============================] - 0s 941us/step - loss: 749.4393 - val_los
s: 488.2314
Epoch 69/600
125/125 [==============================] - 0s 974us/step - loss: 754.1964 - val_los
s: 571.8184
Epoch 70/600
125/125 [==============================] - 0s 936us/step - loss: 610.5428 - val_los
s: 521.0869
Epoch 71/600
125/125 [==============================] - 0s 936us/step - loss: 758.9785 - val_los
s: 437.9417
Epoch 72/600
125/125 [==============================] - 0s 933us/step - loss: 752.3904 - val_los
s: 597.3618
Epoch 73/600
125/125 [==============================] - 0s 940us/step - loss: 834.5992 - val_los
s: 480.8543
Epoch 74/600
125/125 [==============================] - 0s 934us/step - loss: 673.1131 - val_los
s: 379.6210
Epoch 75/600
125/125 [==============================] - 0s 936us/step - loss: 731.6565 - val_los
```

```
s: 395.6931
Epoch 76/600
125/125 [==============================] - 0s 946us/step - loss: 1062.2404 - val_los
s: 426.1862
Epoch 77/600
125/125 [==============================] - 0s 946us/step - loss: 677.5170 - val_los
s: 349.2906
Epoch 78/600
125/125 [==============================] - 0s 960us/step - loss: 1177.7703 - val_los
s: 475.1355
Epoch 79/600
125/125 [==============================] - 0s 940us/step - loss: 1246.9788 - val_los
s: 2026.3497
Epoch 80/600
125/125 [==============================] - 0s 943us/step - loss: 858.4559 - val_los
s: 2395.2734
Epoch 81/600
125/125 [==============================] - 0s 954us/step - loss: 1334.7166 - val_los
s: 322.9944
Epoch 82/600
125/125 [==============================] - 0s 952us/step - loss: 1491.8103 - val_los
s: 986.7665
Epoch 83/600
125/125 [==============================] - 0s 936us/step - loss: 1595.7234 - val_los
s: 3599.5144
Epoch 84/600
125/125 [==============================] - 0s 928us/step - loss: 4938.3384 - val_los
s: 2447.6194
Epoch 85/600
125/125 [==============================] - 0s 941us/step - loss: 4001.5093 - val_los
s: 8488.3027
Epoch 86/600
125/125 [==============================] - 0s 948us/step - loss: 6218.5015 - val_los
s: 11528.7715
Epoch 87/600
125/125 [==============================] - 0s 937us/step - loss: 10073.4727 - val_lo
ss: 806.7758
Epoch 88/600
125/125 [==============================] - 0s 941us/step - loss: 44098.2070 - val_lo
ss: 5868.4810
Epoch 89/600
125/125 [==============================] - 0s 948us/step - loss: 2884.1819 - val_los
s: 860.2871
Epoch 90/600
125/125 [==============================] - 0s 941us/step - loss: 30201.5469 - val_lo
ss: 17130.9941
Epoch 91/600
125/125 [==============================] - 0s 948us/step - loss: 5165.9517 - val_los
s: 5551.3765
Epoch 92/600
125/125 [==============================] - 0s 935us/step - loss: 20160.3262 - val_lo
ss: 26195.2715
Epoch 93/600
125/125 [==============================] - 0s 940us/step - loss: 22687.8633 - val_lo
ss: 20059.5215
Epoch 94/600
```

```
125/125 [==============================] - 0s 946us/step - loss: 44023.2773 - val_lo
ss: 34115.3984
Epoch 95/600
125/125 [==============================] - 0s 945us/step - loss: 7362.5591 - val_los
s: 345.6289
Epoch 96/600
125/125 [==============================] - 0s 947us/step - loss: 4237.7266 - val_los
s: 44919.0781
Epoch 97/600
125/125 [==============================] - 0s 949us/step - loss: 21233.5566 - val_lo
ss: 4623.0293
Epoch 98/600
125/125 [==============================] - 0s 944us/step - loss: 97442.5938 - val_lo
ss: 228.4012
Epoch 99/600
125/125 [==============================] - 0s 950us/step - loss: 417.7679 - val_los
s: 375.6993
Epoch 100/600
125/125 [==============================] - 0s 933us/step - loss: 679.3640 - val_los
s: 239.8168
Epoch 101/600
125/125 [==============================] - 0s 946us/step - loss: 1330.1805 - val_los
s: 264.9565
Epoch 102/600
125/125 [==============================] - 0s 938us/step - loss: 8851.6650 - val_los
s: 61437.9961
Epoch 103/600
125/125 [==============================] - 0s 953us/step - loss: 23605.8164 - val_lo
ss: 490.2524
Epoch 104/600
125/125 [==============================] - 0s 936us/step - loss: 4151.0083 - val_los
s: 821.6905
Epoch 105/600
125/125 [==============================] - 0s 946us/step - loss: 19338.4766 - val_lo
ss: 7129.7378
Epoch 106/600
125/125 [==============================] - 0s 948us/step - loss: 15549.5420 - val_lo
ss: 4332.3291
Epoch 107/600
125/125 [==============================] - 0s 949us/step - loss: 12243.1143 - val_lo
ss: 20617.1777
Epoch 108/600
125/125 [==============================] - 0s 949us/step - loss: 12844.2256 - val_lo
ss: 2083.4531
Epoch 109/600
125/125 [==============================] - 0s 945us/step - loss: 10820.9951 - val_lo
ss: 14426.4902
Epoch 110/600
125/125 [==============================] - 0s 942us/step - loss: 29545.1211 - val_lo
ss: 657.2724
Epoch 111/600
125/125 [==============================] - 0s 939us/step - loss: 853.8504 - val_los
s: 272.7592
Epoch 112/600
125/125 [==============================] - 0s 938us/step - loss: 8586.7178 - val_los
s: 32402.0312
```

```
Epoch 113/600
125/125 [==============================] - 0s 975us/step - loss: 10670.7949 - val_lo
ss: 974.9263
Epoch 114/600
125/125 [==============================] - 0s 959us/step - loss: 10434.4814 - val_lo
ss: 17058.0020
Epoch 115/600
125/125 [==============================] - 0s 941us/step - loss: 11966.3369 - val_lo
ss: 355.6284
Epoch 116/600
125/125 [==============================] - 0s 944us/step - loss: 693.5295 - val_los
s: 1555.3185
Epoch 117/600
125/125 [==============================] - 0s 947us/step - loss: 9399.0039 - val_los
s: 420.8553
Epoch 118/600
125/125 [==============================] - 0s 939us/step - loss: 6402.0405 - val_los
s: 9219.7285
Epoch 119/600
125/125 [==============================] - 0s 936us/step - loss: 7296.2651 - val_los
s: 121997.4375
Epoch 120/600
125/125 [==============================] - 0s 944us/step - loss: 21608.9648 - val_lo
ss: 284.3832
Epoch 121/600
125/125 [==============================] - 0s 926us/step - loss: 339.5434 - val_los
s: 683.6874
Epoch 122/600
125/125 [==============================] - 0s 945us/step - loss: 3876.0835 - val_los
s: 2902.4553
Epoch 123/600
125/125 [==============================] - 0s 942us/step - loss: 1890.0333 - val_los
s: 2016.7931
Epoch 124/600
125/125 [==============================] - 0s 944us/step - loss: 5810.2207 - val_los
s: 21388.3945
Epoch 125/600
125/125 [==============================] - 0s 949us/step - loss: 6512.1113 - val_los
s: 8079.4907
Epoch 126/600
125/125 [==============================] - 0s 940us/step - loss: 6341.3423 - val_los
s: 122.4553
Epoch 127/600
125/125 [==============================] - 0s 944us/step - loss: 846.8793 - val_los
s: 465.5215
Epoch 128/600
125/125 [==============================] - 0s 948us/step - loss: 6274.0283 - val_los
s: 1117.4768
Epoch 129/600
125/125 [==============================] - 0s 946us/step - loss: 1712.0497 - val_los
s: 495.6732
Epoch 130/600
125/125 [==============================] - 0s 935us/step - loss: 3117.7817 - val_los
s: 5761.0688
Epoch 131/600
125/125 [==============================] - 0s 958us/step - loss: 1960.8745 - val_los
```

```
s: 248.2971
Epoch 132/600
125/125 [==============================] - 0s 931us/step - loss: 3707.9050 - val_los
s: 6316.7939
Epoch 133/600
125/125 [==============================] - 0s 944us/step - loss: 5745.0444 - val_los
s: 1230.3436
Epoch 134/600
125/125 [==============================] - 0s 936us/step - loss: 802.3213 - val_los
s: 472.9588
Epoch 135/600
125/125 [==============================] - 0s 939us/step - loss: 2402.5447 - val_los
s: 703.8463
Epoch 136/600
125/125 [==============================] - 0s 943us/step - loss: 5771.3145 - val_los
s: 632.0864
Epoch 137/600
125/125 [==============================] - 0s 944us/step - loss: 454.8114 - val_los
s: 130.5993
Epoch 138/600
125/125 [==============================] - 0s 939us/step - loss: 5256.2495 - val_los
s: 388.2206
Epoch 139/600
125/125 [==============================] - 0s 947us/step - loss: 439.6642 - val_los
s: 52.8147
Epoch 140/600
125/125 [==============================] - 0s 951us/step - loss: 235.7372 - val_los
s: 749.9799
Epoch 141/600
125/125 [==============================] - 0s 942us/step - loss: 559.5712 - val_los
s: 894.8829
Epoch 142/600
125/125 [==============================] - 0s 942us/step - loss: 4246.6118 - val_los
s: 114.9303
Epoch 143/600
125/125 [==============================] - 0s 940us/step - loss: 373.5894 - val_los
s: 487.0881
Epoch 144/600
125/125 [==============================] - 0s 947us/step - loss: 308.7049 - val_los
s: 1176.8020
Epoch 145/600
125/125 [==============================] - 0s 945us/step - loss: 713.3296 - val_los
s: 109.6760
Epoch 146/600
125/125 [==============================] - 0s 948us/step - loss: 2545.0037 - val_los
s: 420.0151
Epoch 147/600
125/125 [==============================] - 0s 943us/step - loss: 502.4804 - val_los
s: 5209.7407
Epoch 148/600
125/125 [==============================] - 0s 928us/step - loss: 910.9147 - val_los
s: 98.4271
Epoch 149/600
125/125 [==============================] - 0s 960us/step - loss: 1482.2731 - val_los
s: 33311.1328
Epoch 150/600
```

```
125/125 [==============================] - 0s 943us/step - loss: 5308.6587 - val_los
s: 31.0927
Epoch 151/600
125/125 [==============================] - 0s 938us/step - loss: 62.5691 - val_loss:
53.3165
Epoch 152/600
125/125 [==============================] - 0s 947us/step - loss: 51.7583 - val_loss:
124.7220
Epoch 153/600
125/125 [==============================] - 0s 938us/step - loss: 76.7934 - val_loss:
62.5165
Epoch 154/600
125/125 [==============================] - 0s 937us/step - loss: 74.2726 - val_loss:
97.3857
Epoch 155/600
125/125 [==============================] - 0s 932us/step - loss: 108.5338 - val_los
s: 169.6882
Epoch 156/600
125/125 [==============================] - 0s 965us/step - loss: 315.3025 - val_los
s: 47.3723
Epoch 157/600
125/125 [==============================] - 0s 942us/step - loss: 916.6986 - val_los
s: 52.3664
Epoch 158/600
125/125 [==============================] - 0s 941us/step - loss: 194.5224 - val_los
s: 56.6394
Epoch 159/600
125/125 [==============================] - 0s 955us/step - loss: 334.9358 - val_los
s: 2558.4807
Epoch 160/600
125/125 [==============================] - 0s 942us/step - loss: 492.0158 - val_los
s: 57.9927
Epoch 161/600
125/125 [==============================] - 0s 954us/step - loss: 598.0574 - val_los
s: 243.7272
Epoch 162/600
125/125 [==============================] - 0s 932us/step - loss: 172.3778 - val_los
s: 34.9272
Epoch 163/600
125/125 [==============================] - 0s 940us/step - loss: 934.5539 - val_los
s: 30.6647
Epoch 164/600
125/125 [==============================] - 0s 928us/step - loss: 129.1150 - val_los
s: 25.3110
Epoch 165/600
125/125 [==============================] - 0s 932us/step - loss: 93.5037 - val_loss:
114.7529
Epoch 166/600
125/125 [==============================] - 0s 948us/step - loss: 194.5799 - val_los
s: 78.8786
Epoch 167/600
125/125 [==============================] - 0s 940us/step - loss: 1075.5444 - val_los
s: 509.1085
Epoch 168/600
125/125 [==============================] - 0s 942us/step - loss: 157.5690 - val_los
s: 16.0887
```

```
Epoch 169/600
125/125 [==============================] - 0s 944us/step - loss: 63.9946 - val_loss:
35.9673
Epoch 170/600
125/125 [==============================] - 0s 951us/step - loss: 67.5534 - val_loss:
18.2196
Epoch 171/600
125/125 [==============================] - 0s 956us/step - loss: 168.6944 - val_los
s: 456.1453
Epoch 172/600
125/125 [==============================] - 0s 937us/step - loss: 709.4559 - val_los
s: 94.6872
Epoch 173/600
125/125 [==============================] - 0s 936us/step - loss: 119.5879 - val_los
s: 77.2884
Epoch 174/600
125/125 [==============================] - 0s 938us/step - loss: 68.9836 - val_loss:
19.3656
Epoch 175/600
125/125 [==============================] - 0s 946us/step - loss: 175.6770 - val_los
s: 677.3408
Epoch 176/600
125/125 [==============================] - 0s 938us/step - loss: 310.3793 - val_los
s: 23.0918
Epoch 177/600
125/125 [==============================] - 0s 944us/step - loss: 56.2572 - val_loss:
12.3676
Epoch 178/600
125/125 [==============================] - 0s 951us/step - loss: 405.9881 - val_los
s: 381.3550
Epoch 179/600
125/125 [==============================] - 0s 968us/step - loss: 180.0585 - val_los
s: 7.7418
Epoch 180/600
125/125 [==============================] - 0s 952us/step - loss: 14.0000 - val_loss:
7.5871
Epoch 181/600
125/125 [==============================] - 0s 940us/step - loss: 29.7552 - val_loss:
11.1510
Epoch 182/600
125/125 [==============================] - 0s 944us/step - loss: 63.5266 - val_loss:
548.1908
Epoch 183/600
125/125 [==============================] - 0s 940us/step - loss: 244.3813 - val_los
s: 56.1533
Epoch 184/600
125/125 [==============================] - 0s 936us/step - loss: 113.3131 - val_los
s: 10.7425
Epoch 185/600
125/125 [==============================] - 0s 941us/step - loss: 65.6736 - val_loss:
53.5913
Epoch 186/600
125/125 [==============================] - 0s 950us/step - loss: 45.6273 - val_loss:
73.8190
Epoch 187/600
125/125 [==============================] - 0s 950us/step - loss: 182.7239 - val_los
```

```
s: 656.6247
Epoch 188/600
125/125 [==============================] - 0s 950us/step - loss: 149.6267 - val_los
s: 6.1328
Epoch 189/600
125/125 [==============================] - 0s 957us/step - loss: 18.0495 - val_loss:
7.3389
Epoch 190/600
125/125 [==============================] - 0s 934us/step - loss: 40.4299 - val_loss:
35.2476
Epoch 191/600
125/125 [==============================] - 0s 949us/step - loss: 154.6615 - val_los
s: 7.6579
Epoch 192/600
125/125 [==============================] - 0s 946us/step - loss: 11.1999 - val_loss:
2.6782
Epoch 193/600
125/125 [==============================] - 0s 948us/step - loss: 52.9612 - val_loss:
43.6082
Epoch 194/600
125/125 [==============================] - 0s 960us/step - loss: 96.7617 - val_loss:
10.6598
Epoch 195/600
125/125 [==============================] - 0s 936us/step - loss: 24.8540 - val_loss:
57.7062
Epoch 196/600
125/125 [==============================] - 0s 938us/step - loss: 8.2403 - val_loss:
3.3224
Epoch 197/600
125/125 [==============================] - 0s 947us/step - loss: 89.9535 - val_loss:
96.2533
Epoch 198/600
125/125 [==============================] - 0s 941us/step - loss: 37.7227 - val_loss:
3.3527
Epoch 199/600
125/125 [==============================] - 0s 932us/step - loss: 324.9435 - val_los
s: 15.2633
Epoch 200/600
125/125 [==============================] - 0s 948us/step - loss: 1.7207 - val_loss:
0.5754
Epoch 201/600
125/125 [==============================] - 0s 941us/step - loss: 1.3476 - val_loss:
1.5928
Epoch 202/600
125/125 [==============================] - 0s 940us/step - loss: 1.9853 - val_loss:
0.4158
Epoch 203/600
125/125 [==============================] - 0s 937us/step - loss: 2.8503 - val_loss:
4.4234
Epoch 204/600
125/125 [==============================] - 0s 928us/step - loss: 3.2052 - val_loss:
4.6812
Epoch 205/600
125/125 [==============================] - 0s 929us/step - loss: 3.5799 - val_loss:
6.8483
Epoch 206/600
```

```
125/125 [==============================] - 0s 946us/step - loss: 23.4335 - val_loss:
66.8272
Epoch 207/600
125/125 [==============================] - 0s 946us/step - loss: 191.4816 - val_los
s: 1.4675
Epoch 208/600
125/125 [==============================] - 0s 988us/step - loss: 0.9307 - val_loss:
1.3318
Epoch 209/600
125/125 [==============================] - 0s 938us/step - loss: 0.9895 - val_loss:
0.2657
Epoch 210/600
125/125 [==============================] - 0s 928us/step - loss: 1.6074 - val_loss:
1.0808
Epoch 211/600
125/125 [==============================] - 0s 936us/step - loss: 0.7035 - val_loss:
0.5721
Epoch 212/600
125/125 [==============================] - 0s 932us/step - loss: 1.0095 - val_loss:
1.6327
Epoch 213/600
125/125 [==============================] - 0s 932us/step - loss: 3.5791 - val_loss:
0.3322
Epoch 214/600
125/125 [==============================] - 0s 940us/step - loss: 85.4546 - val_loss:
237.3506
Epoch 215/600
125/125 [==============================] - 0s 941us/step - loss: 77.1961 - val_loss:
2.7715
Epoch 216/600
125/125 [==============================] - 0s 934us/step - loss: 0.8709 - val_loss:
0.3518
Epoch 217/600
125/125 [==============================] - 0s 932us/step - loss: 0.7654 - val_loss:
0.2619
Epoch 218/600
125/125 [==============================] - 0s 936us/step - loss: 0.4063 - val_loss:
0.2060
Epoch 219/600
125/125 [==============================] - 0s 937us/step - loss: 0.3042 - val_loss:
0.3872
Epoch 220/600
125/125 [==============================] - 0s 932us/step - loss: 3.7065 - val_loss:
1.2513
Epoch 221/600
125/125 [==============================] - 0s 936us/step - loss: 2.1582 - val_loss:
0.5911
Epoch 222/600
125/125 [==============================] - 0s 936us/step - loss: 15.1355 - val_loss:
2.2303
Epoch 223/600
125/125 [==============================] - 0s 936us/step - loss: 2.1881 - val_loss:
4.6271
Epoch 224/600
125/125 [==============================] - 0s 938us/step - loss: 44.1648 - val_loss:
84.0281
```

```
Epoch 225/600
125/125 [==============================] - 0s 937us/step - loss: 15.1741 - val_loss:
0.8519
Epoch 226/600
125/125 [==============================] - 0s 928us/step - loss: 0.5583 - val_loss:
0.9064
Epoch 227/600
125/125 [==============================] - 0s 938us/step - loss: 1.0571 - val_loss:
1.6183
Epoch 228/600
125/125 [==============================] - 0s 932us/step - loss: 1.6043 - val_loss:
2.3728
Epoch 229/600
125/125 [==============================] - 0s 943us/step - loss: 2.7913 - val_loss:
0.2135
Epoch 230/600
125/125 [==============================] - 0s 933us/step - loss: 3.6594 - val_loss:
0.8041
Epoch 231/600
125/125 [==============================] - 0s 933us/step - loss: 5.2156 - val_loss:
39.2556
Epoch 232/600
125/125 [==============================] - 0s 941us/step - loss: 19.8258 - val_loss:
0.4622
Epoch 233/600
125/125 [==============================] - 0s 932us/step - loss: 0.5543 - val_loss:
0.7796
Epoch 234/600
125/125 [==============================] - 0s 936us/step - loss: 3.3183 - val_loss:
0.2190
Epoch 235/600
125/125 [==============================] - 0s 948us/step - loss: 2.4849 - val_loss:
0.7014
Epoch 236/600
125/125 [==============================] - 0s 936us/step - loss: 21.4650 - val_loss:
1.1734
Epoch 237/600
125/125 [==============================] - 0s 977us/step - loss: 0.3841 - val_loss:
0.1675
Epoch 238/600
125/125 [==============================] - 0s 932us/step - loss: 0.5219 - val_loss:
1.4891
Epoch 239/600
125/125 [==============================] - 0s 936us/step - loss: 4.8458 - val_loss:
3.0948
Epoch 240/600
125/125 [==============================] - 0s 936us/step - loss: 2.5105 - val_loss:
0.1813
Epoch 241/600
125/125 [==============================] - 0s 956us/step - loss: 20.2555 - val_loss:
8.4712
Epoch 242/600
125/125 [==============================] - 0s 940us/step - loss: 0.7009 - val_loss:
0.0977
Epoch 243/600
125/125 [==============================] - 0s 937us/step - loss: 0.1387 - val_loss:
```

```
0.0611
Epoch 244/600
125/125 [==============================] - 0s 939us/step - loss: 0.1559 - val_loss:
0.1215
Epoch 245/600
125/125 [==============================] - 0s 940us/step - loss: 0.1528 - val_loss:
0.3629
Epoch 246/600
125/125 [==============================] - 0s 941us/step - loss: 1.1092 - val_loss:
0.5755
Epoch 247/600
125/125 [==============================] - 0s 938us/step - loss: 1.3260 - val_loss:
0.1210
Epoch 248/600
125/125 [==============================] - 0s 936us/step - loss: 46.4663 - val_loss:
0.1121
Epoch 249/600
125/125 [==============================] - 0s 945us/step - loss: 0.0538 - val_loss:
0.0354
Epoch 250/600
125/125 [==============================] - 0s 940us/step - loss: 0.0317 - val_loss:
0.0571
Epoch 251/600
125/125 [==============================] - 0s 946us/step - loss: 0.0391 - val_loss:
0.0346
Epoch 252/600
125/125 [==============================] - 0s 935us/step - loss: 0.0321 - val_loss:
0.0237
Epoch 253/600
125/125 [==============================] - 0s 935us/step - loss: 0.0333 - val_loss:
0.0218
Epoch 254/600
125/125 [==============================] - 0s 940us/step - loss: 0.0258 - val_loss:
0.0255
Epoch 255/600
125/125 [==============================] - 0s 940us/step - loss: 0.0253 - val_loss:
0.0217
Epoch 256/600
125/125 [==============================] - 0s 935us/step - loss: 0.0231 - val_loss:
0.0280
Epoch 257/600
125/125 [==============================] - 0s 932us/step - loss: 0.0239 - val_loss:
0.0457
Epoch 258/600
125/125 [==============================] - 0s 934us/step - loss: 0.0293 - val_loss:
0.0372
Epoch 259/600
125/125 [==============================] - 0s 936us/step - loss: 0.0430 - val_loss:
0.0456
Epoch 260/600
125/125 [==============================] - 0s 940us/step - loss: 0.0374 - val_loss:
0.0189
Epoch 261/600
125/125 [==============================] - 0s 962us/step - loss: 0.0637 - val_loss:
0.0144
Epoch 262/600
```

```
125/125 [==============================] - 0s 942us/step - loss: 0.1497 - val_loss:
0.2323
Epoch 263/600
125/125 [==============================] - 0s 934us/step - loss: 3.4449 - val_loss:
0.2133
Epoch 264/600
125/125 [==============================] - 0s 935us/step - loss: 0.0660 - val_loss:
0.0167
Epoch 265/600
125/125 [==============================] - 0s 928us/step - loss: 0.1003 - val_loss:
0.1366
Epoch 266/600
125/125 [==============================] - 0s 932us/step - loss: 3.0583 - val_loss:
0.8563
Epoch 267/600
125/125 [==============================] - 0s 938us/step - loss: 0.1366 - val_loss:
0.1453
Epoch 268/600
125/125 [==============================] - 0s 936us/step - loss: 0.0707 - val_loss:
0.0230
Epoch 269/600
125/125 [==============================] - 0s 938us/step - loss: 1.4422 - val_loss:
0.7544
Epoch 270/600
125/125 [==============================] - 0s 936us/step - loss: 1.4904 - val_loss:
0.0110
Epoch 271/600
125/125 [==============================] - 0s 942us/step - loss: 0.0673 - val_loss:
0.0593
Epoch 272/600
125/125 [==============================] - 0s 940us/step - loss: 3.0964 - val_loss:
25.9112
Epoch 273/600
125/125 [==============================] - 0s 931us/step - loss: 3.2007 - val_loss:
0.0126
Epoch 274/600
125/125 [==============================] - 0s 936us/step - loss: 0.0091 - val_loss:
0.0089
Epoch 275/600
125/125 [==============================] - 0s 940us/step - loss: 0.0080 - val_loss:
0.0079
Epoch 276/600
125/125 [==============================] - 0s 936us/step - loss: 0.0096 - val_loss:
0.0063
Epoch 277/600
125/125 [==============================] - 0s 944us/step - loss: 0.0080 - val_loss:
0.0059
Epoch 278/600
125/125 [==============================] - 0s 938us/step - loss: 0.0464 - val_loss:
0.0442
Epoch 279/600
125/125 [==============================] - 0s 940us/step - loss: 0.0725 - val_loss:
0.0461
Epoch 280/600
125/125 [==============================] - 0s 940us/step - loss: 0.5939 - val_loss:
13.3144
```

```
Epoch 281/600
125/125 [==============================] - 0s 932us/step - loss: 0.7005 - val_loss:
0.1353
Epoch 282/600
125/125 [==============================] - 0s 944us/step - loss: 0.4523 - val_loss:
0.0887
Epoch 283/600
125/125 [==============================] - 0s 936us/step - loss: 0.2686 - val_loss:
0.1484
Epoch 284/600
125/125 [==============================] - 0s 924us/step - loss: 0.9741 - val_loss:
0.7618
Epoch 285/600
125/125 [==============================] - 0s 960us/step - loss: 0.1761 - val_loss:
0.0076
Epoch 286/600
125/125 [==============================] - 0s 936us/step - loss: 0.9434 - val_loss:
0.0752
Epoch 287/600
125/125 [==============================] - 0s 936us/step - loss: 0.0470 - val_loss:
0.0300
Epoch 288/600
125/125 [==============================] - 0s 932us/step - loss: 0.2222 - val_loss:
5.9786
Epoch 289/600
125/125 [==============================] - 0s 928us/step - loss: 0.8410 - val_loss:
0.3831
Epoch 290/600
125/125 [==============================] - 0s 932us/step - loss: 0.0516 - val_loss:
0.0685
Epoch 291/600
125/125 [==============================] - 0s 936us/step - loss: 0.5672 - val_loss:
0.2285
Epoch 292/600
125/125 [==============================] - 0s 932us/step - loss: 0.5441 - val_loss:
0.1164
Epoch 293/600
125/125 [==============================] - 0s 955us/step - loss: 0.1319 - val_loss:
0.2961
Epoch 294/600
125/125 [==============================] - 0s 928us/step - loss: 0.1428 - val_loss:
0.0090
Epoch 295/600
125/125 [==============================] - 0s 932us/step - loss: 0.1946 - val_loss:
0.0133
Epoch 296/600
125/125 [==============================] - 0s 932us/step - loss: 1.6970 - val_loss:
4.7658
Epoch 297/600
125/125 [==============================] - 0s 928us/step - loss: 0.2713 - val_loss:
0.0023
Epoch 298/600
125/125 [==============================] - 0s 932us/step - loss: 0.0018 - val_loss:
8.4000e-04
Epoch 299/600
125/125 [==============================] - 0s 929us/step - loss: 0.0025 - val_loss:
```

```
0.0016
Epoch 300/600
125/125 [==============================] - 0s 936us/step - loss: 0.0191 - val_loss: 
0.1160
Epoch 301/600
125/125 [==============================] - 0s 931us/step - loss: 0.2570 - val_loss: 
0.0118
Epoch 302/600
125/125 [==============================] - 0s 930us/step - loss: 0.0824 - val_loss: 
7.4690e-04
Epoch 303/600
125/125 [==============================] - 0s 939us/step - loss: 0.0889 - val_loss: 
0.2419
Epoch 304/600
125/125 [==============================] - 0s 934us/step - loss: 1.0051 - val_loss: 
0.0115
Epoch 305/600
125/125 [==============================] - 0s 932us/step - loss: 0.0013 - val_loss: 
5.7291e-04
Epoch 306/600
125/125 [==============================] - 0s 956us/step - loss: 0.0016 - val_loss: 
2.6593e-04
Epoch 307/600
125/125 [==============================] - 0s 948us/step - loss: 0.0034 - val_loss: 
0.0605
Epoch 308/600
125/125 [==============================] - 0s 928us/step - loss: 0.2751 - val_loss: 
0.1236
Epoch 309/600
125/125 [==============================] - 0s 937us/step - loss: 0.0723 - val_loss: 
0.0020
Epoch 310/600
125/125 [==============================] - 0s 932us/step - loss: 0.4036 - val_loss: 
0.0231
Epoch 311/600
125/125 [==============================] - 0s 933us/step - loss: 0.0127 - val_loss: 
0.0938
Epoch 312/600
125/125 [==============================] - 0s 931us/step - loss: 1.0027 - val_loss: 
0.0063
Epoch 313/600
125/125 [==============================] - 0s 928us/step - loss: 0.0039 - val_loss: 
4.6858e-04
Epoch 314/600
125/125 [==============================] - 0s 928us/step - loss: 0.0020 - val_loss: 
9.5985e-04
Epoch 315/600
125/125 [==============================] - 0s 932us/step - loss: 0.0017 - val_loss: 
0.0023
Epoch 316/600
125/125 [==============================] - 0s 933us/step - loss: 0.0214 - val_loss: 
0.0359
Epoch 317/600
125/125 [==============================] - 0s 936us/step - loss: 0.1814 - val_loss: 
0.2756
Epoch 318/600
```

```
125/125 [==============================] - 0s 936us/step - loss: 0.5005 - val_loss:
0.0010
Epoch 319/600
125/125 [==============================] - 0s 935us/step - loss: 2.3947e-04 - val_lo
ss: 1.1497e-04
Epoch 320/600
125/125 [==============================] - 0s 944us/step - loss: 5.5663e-04 - val_lo
ss: 0.0032
Epoch 321/600
125/125 [==============================] - 0s 944us/step - loss: 3.2543 - val_loss:
15.5338
Epoch 322/600
125/125 [==============================] - 0s 936us/step - loss: 0.6756 - val_loss:
0.0058
Epoch 323/600
125/125 [==============================] - 0s 928us/step - loss: 0.0027 - val_loss:
0.0010
Epoch 324/600
125/125 [==============================] - 0s 940us/step - loss: 5.7358e-04 - val_lo
ss: 1.9076e-04
Epoch 325/600
125/125 [==============================] - 0s 941us/step - loss: 1.4556e-04 - val_lo
ss: 1.7681e-04
Epoch 326/600
125/125 [==============================] - 0s 931us/step - loss: 7.8444e-05 - val_lo
ss: 2.1057e-04
Epoch 327/600
125/125 [==============================] - 0s 952us/step - loss: 8.2054e-05 - val_lo
ss: 4.9664e-05
Epoch 328/600
125/125 [==============================] - 0s 927us/step - loss: 6.1505e-05 - val_lo
ss: 4.3848e-05
Epoch 329/600
125/125 [==============================] - 0s 926us/step - loss: 8.2938e-05 - val_lo
ss: 1.3562e-04
Epoch 330/600
125/125 [==============================] - 0s 928us/step - loss: 7.1800e-05 - val_lo
ss: 6.5467e-05
Epoch 331/600
125/125 [==============================] - 0s 932us/step - loss: 1.0081e-04 - val_lo
ss: 5.3193e-05
Epoch 332/600
125/125 [==============================] - 0s 932us/step - loss: 1.8227e-04 - val_lo
ss: 9.9064e-05
Epoch 333/600
125/125 [==============================] - 0s 933us/step - loss: 9.7618e-05 - val_lo
ss: 2.8471e-04
Epoch 334/600
125/125 [==============================] - 0s 948us/step - loss: 1.4792e-04 - val_lo
ss: 5.2122e-05
Epoch 335/600
125/125 [==============================] - 0s 936us/step - loss: 0.0048 - val_loss:
0.0035
Epoch 336/600
125/125 [==============================] - 0s 933us/step - loss: 0.0383 - val_loss:
0.1603
```

```
Epoch 337/600
125/125 [==============================] - 0s 931us/step - loss: 0.0752 - val_loss:
1.3132e-04
Epoch 338/600
125/125 [==============================] - 0s 932us/step - loss: 0.0979 - val_loss:
0.0661
Epoch 339/600
125/125 [==============================] - 0s 940us/step - loss: 0.0323 - val_loss:
0.0406
Epoch 340/600
125/125 [==============================] - 0s 972us/step - loss: 0.0902 - val_loss:
0.0248
Epoch 341/600
125/125 [==============================] - 0s 924us/step - loss: 0.0234 - val_loss:
0.0320
Epoch 342/600
125/125 [==============================] - 0s 932us/step - loss: 0.1036 - val_loss:
0.0037
Epoch 343/600
125/125 [==============================] - 0s 956us/step - loss: 0.0797 - val_loss:
0.0172
Epoch 344/600
125/125 [==============================] - 0s 932us/step - loss: 0.0831 - val_loss:
4.4520
Epoch 345/600
125/125 [==============================] - 0s 928us/step - loss: 0.3319 - val_loss:
4.9724e-04
Epoch 346/600
125/125 [==============================] - 0s 936us/step - loss: 4.4309e-04 - val_lo
ss: 3.1672e-04
Epoch 347/600
125/125 [==============================] - 0s 940us/step - loss: 5.5277e-04 - val_lo
ss: 3.7769e-04
Epoch 348/600
125/125 [==============================] - 0s 961us/step - loss: 0.0011 - val_loss:
8.4644e-04
Epoch 349/600
125/125 [==============================] - 0s 932us/step - loss: 0.0013 - val_loss:
0.0011
Epoch 350/600
125/125 [==============================] - 0s 936us/step - loss: 1864.0927 - val_los
s: 0.7576
Epoch 351/600
125/125 [==============================] - 0s 932us/step - loss: 0.5156 - val_loss:
0.3575
Epoch 352/600
125/125 [==============================] - 0s 937us/step - loss: 0.3641 - val_loss:
0.3444
Epoch 353/600
125/125 [==============================] - 0s 940us/step - loss: 0.3244 - val_loss:
0.2941
Epoch 354/600
125/125 [==============================] - 0s 948us/step - loss: 0.2875 - val_loss:
0.2559
Epoch 355/600
125/125 [==============================] - 0s 932us/step - loss: 0.2632 - val_loss:
```

```
0.3569
Epoch 356/600
125/125 [==============================] - 0s 929us/step - loss: 0.2445 - val_loss:
0.2108
Epoch 357/600
125/125 [==============================] - 0s 938us/step - loss: 0.2319 - val_loss:
0.2321
Epoch 358/600
125/125 [==============================] - 0s 935us/step - loss: 0.1957 - val_loss:
0.1792
Epoch 359/600
125/125 [==============================] - 0s 943us/step - loss: 0.1756 - val_loss:
0.1533
Epoch 360/600
125/125 [==============================] - 0s 943us/step - loss: 0.1518 - val_loss:
0.1554
Epoch 361/600
125/125 [==============================] - 0s 968us/step - loss: 0.1413 - val_loss:
0.1327
Epoch 362/600
125/125 [==============================] - 0s 950us/step - loss: 0.1264 - val_loss:
0.1148
Epoch 363/600
125/125 [==============================] - 0s 932us/step - loss: 0.1323 - val_loss:
0.1347
Epoch 364/600
125/125 [==============================] - 0s 940us/step - loss: 0.1079 - val_loss:
0.0919
Epoch 365/600
125/125 [==============================] - 0s 936us/step - loss: 0.0924 - val_loss:
0.0848
Epoch 366/600
125/125 [==============================] - 0s 936us/step - loss: 0.0814 - val_loss:
0.0718
Epoch 367/600
125/125 [==============================] - 0s 968us/step - loss: 0.0752 - val_loss:
0.0618
Epoch 368/600
125/125 [==============================] - 0s 929us/step - loss: 0.0642 - val_loss:
0.0584
Epoch 369/600
125/125 [==============================] - 0s 932us/step - loss: 0.0628 - val_loss:
0.0540
Epoch 370/600
125/125 [==============================] - 0s 936us/step - loss: 0.0517 - val_loss:
0.0578
Epoch 371/600
125/125 [==============================] - 0s 956us/step - loss: 0.0464 - val_loss:
0.0421
Epoch 372/600
125/125 [==============================] - 0s 932us/step - loss: 0.0410 - val_loss:
0.0388
Epoch 373/600
125/125 [==============================] - 0s 930us/step - loss: 0.0386 - val_loss:
0.0431
Epoch 374/600
```

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125/125 [==============================] - 0s 920us/step - loss: 0.0302 - val_loss: 
0.0231
Epoch 375/600
125/125 [==============================] - 0s 924us/step - loss: 0.0314 - val_loss: 
0.0373
Epoch 376/600
125/125 [==============================] - 0s 925us/step - loss: 0.0225 - val_loss: 
0.0220
Epoch 377/600
125/125 [==============================] - 0s 921us/step - loss: 0.0244 - val_loss: 
0.0163
Epoch 378/600
125/125 [==============================] - 0s 952us/step - loss: 0.0205 - val_loss: 
0.0129
Epoch 379/600
125/125 [==============================] - 0s 936us/step - loss: 0.0217 - val_loss: 
0.0155
Epoch 380/600
125/125 [==============================] - 0s 935us/step - loss: 0.0231 - val_loss: 
0.0195
Epoch 381/600
125/125 [==============================] - 0s 932us/step - loss: 0.0203 - val_loss: 
0.0136
Epoch 382/600
125/125 [==============================] - 0s 942us/step - loss: 0.0241 - val_loss: 
0.0103
Epoch 383/600
125/125 [==============================] - 0s 936us/step - loss: 0.0211 - val_loss: 
0.0074
Epoch 384/600
125/125 [==============================] - 0s 932us/step - loss: 0.0427 - val_loss: 
0.0075
Epoch 385/600
125/125 [==============================] - 0s 970us/step - loss: 0.0723 - val_loss: 
0.1248
Epoch 386/600
125/125 [==============================] - 0s 936us/step - loss: 0.0563 - val_loss: 
0.1165
Epoch 387/600
125/125 [==============================] - 0s 930us/step - loss: 0.1976 - val_loss: 
0.1322
Epoch 388/600
125/125 [==============================] - 0s 936us/step - loss: 0.0275 - val_loss: 
0.0284
Epoch 389/600
125/125 [==============================] - 0s 936us/step - loss: 0.0390 - val_loss: 
0.0074
Epoch 390/600
125/125 [==============================] - 0s 923us/step - loss: 0.0933 - val_loss: 
0.0723
Epoch 391/600
125/125 [==============================] - 0s 924us/step - loss: 0.0817 - val_loss: 
0.0236
Epoch 392/600
125/125 [==============================] - 0s 932us/step - loss: 0.0888 - val_loss: 
0.0703
```

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Epoch 393/600
125/125 [==============================] - 0s 933us/step - loss: 0.1080 - val_loss:
0.0599
Epoch 394/600
125/125 [==============================] - 0s 940us/step - loss: 0.0532 - val_loss:
0.1749
Epoch 395/600
125/125 [==============================] - 0s 936us/step - loss: 0.2843 - val_loss:
0.0119
Epoch 396/600
125/125 [==============================] - 0s 932us/step - loss: 0.0146 - val_loss:
0.0146
Epoch 397/600
125/125 [==============================] - 0s 937us/step - loss: 0.0452 - val_loss:
0.0422
Epoch 398/600
125/125 [==============================] - 0s 935us/step - loss: 0.1181 - val_loss:
0.0246
Epoch 399/600
125/125 [==============================] - 0s 924us/step - loss: 0.0520 - val_loss:
0.0396
Epoch 400/600
125/125 [==============================] - 0s 932us/step - loss: 0.1618 - val_loss:
0.0278
Epoch 401/600
125/125 [==============================] - 0s 928us/step - loss: 0.0430 - val_loss:
0.0215
Epoch 402/600
125/125 [==============================] - 0s 956us/step - loss: 0.1777 - val_loss:
0.0484
Epoch 403/600
125/125 [==============================] - 0s 932us/step - loss: 0.0874 - val_loss:
0.3874
Epoch 404/600
125/125 [==============================] - 0s 928us/step - loss: 0.1562 - val_loss:
0.0559
Epoch 405/600
125/125 [==============================] - 0s 944us/step - loss: 0.0136 - val_loss:
0.0144
Epoch 406/600
125/125 [==============================] - 0s 932us/step - loss: 0.0768 - val_loss:
0.0715
Epoch 407/600
125/125 [==============================] - 0s 934us/step - loss: 0.0707 - val_loss:
0.0682
Epoch 408/600
125/125 [==============================] - 0s 932us/step - loss: 0.1546 - val_loss:
0.0053
Epoch 409/600
125/125 [==============================] - 0s 932us/step - loss: 0.0561 - val_loss:
0.5150
Epoch 410/600
125/125 [==============================] - 0s 936us/step - loss: 0.0884 - val_loss:
0.0234
Epoch 411/600
125/125 [==============================] - 0s 928us/step - loss: 0.0623 - val_loss:
```

```
0.0114
Epoch 412/600
125/125 [==============================] - 0s 927us/step - loss: 0.1563 - val_loss:
0.0080
Epoch 413/600
125/125 [==============================] - 0s 935us/step - loss: 0.0150 - val_loss:
0.1117
Epoch 414/600
125/125 [==============================] - 0s 936us/step - loss: 0.2625 - val_loss:
0.0305
Epoch 415/600
125/125 [==============================] - 0s 929us/step - loss: 0.0173 - val_loss:
0.0222
Epoch 416/600
125/125 [==============================] - 0s 932us/step - loss: 0.0129 - val_loss:
0.0167
Epoch 417/600
125/125 [==============================] - 0s 932us/step - loss: 0.0726 - val_loss:
0.0061
Epoch 418/600
125/125 [==============================] - 0s 928us/step - loss: 0.0206 - val_loss:
0.0302
Epoch 419/600
125/125 [==============================] - 0s 932us/step - loss: 0.1465 - val_loss:
0.0184
Epoch 420/600
125/125 [==============================] - 0s 936us/step - loss: 0.0146 - val_loss:
0.0252
Epoch 421/600
125/125 [==============================] - 0s 960us/step - loss: 0.0782 - val_loss:
0.0300
Epoch 422/600
125/125 [==============================] - 0s 936us/step - loss: 0.0366 - val_loss:
0.1169
Epoch 423/600
125/125 [==============================] - 0s 935us/step - loss: 0.0365 - val_loss:
0.0067
Epoch 424/600
125/125 [==============================] - 0s 937us/step - loss: 0.0985 - val_loss:
0.0034
Epoch 425/600
125/125 [==============================] - 0s 931us/step - loss: 0.0263 - val_loss:
0.0113
Epoch 426/600
125/125 [==============================] - 0s 935us/step - loss: 0.0788 - val_loss:
0.0067
Epoch 427/600
125/125 [==============================] - 0s 930us/step - loss: 0.0250 - val_loss:
0.0014
Epoch 428/600
125/125 [==============================] - 0s 930us/step - loss: 0.1147 - val_loss:
0.0034
Epoch 429/600
125/125 [==============================] - 0s 935us/step - loss: 0.0039 - val_loss:
0.0016
Epoch 430/600
```

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125/125 [==============================] - 0s 944us/step - loss: 0.0167 - val_loss:
0.0029
Epoch 431/600
125/125 [==============================] - 0s 946us/step - loss: 0.0430 - val_loss:
0.0327
Epoch 432/600
125/125 [==============================] - 0s 935us/step - loss: 0.0728 - val_loss:
0.0053
Epoch 433/600
125/125 [==============================] - 0s 933us/step - loss: 0.0083 - val_loss:
0.0159
Epoch 434/600
125/125 [==============================] - 0s 930us/step - loss: 0.0243 - val_loss:
0.0069
Epoch 435/600
125/125 [==============================] - 0s 933us/step - loss: 0.0393 - val_loss:
0.0634
Epoch 436/600
125/125 [==============================] - 0s 936us/step - loss: 0.0337 - val_loss:
0.0042
Epoch 437/600
125/125 [==============================] - 0s 937us/step - loss: 0.0874 - val_loss:
0.0071
Epoch 438/600
125/125 [==============================] - 0s 962us/step - loss: 0.0042 - val_loss:
0.0011
Epoch 439/600
125/125 [==============================] - 0s 938us/step - loss: 0.0096 - val_loss:
0.0039
Epoch 440/600
125/125 [==============================] - 0s 943us/step - loss: 0.0288 - val_loss:
0.0048
Epoch 441/600
125/125 [==============================] - 0s 936us/step - loss: 0.0698 - val_loss:
0.0582
Epoch 442/600
125/125 [==============================] - 0s 927us/step - loss: 0.0214 - val_loss:
0.0062
Epoch 443/600
125/125 [==============================] - 0s 932us/step - loss: 0.0071 - val_loss:
9.8442e-04
Epoch 444/600
125/125 [==============================] - 0s 933us/step - loss: 0.0059 - val_loss:
0.1113
Epoch 445/600
125/125 [==============================] - 0s 925us/step - loss: 0.0504 - val_loss:
0.0024
Epoch 446/600
125/125 [==============================] - 0s 936us/step - loss: 0.0037 - val_loss:
0.0065
Epoch 447/600
125/125 [==============================] - 0s 938us/step - loss: 0.0062 - val_loss:
0.0036
Epoch 448/600
125/125 [==============================] - 0s 936us/step - loss: 0.0469 - val_loss:
0.0337
```

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Epoch 449/600
125/125 [==============================] - 0s 932us/step - loss: 0.0066 - val_loss:
7.8102e-04
Epoch 450/600
125/125 [==============================] - 0s 937us/step - loss: 0.0180 - val_loss:
0.0693
Epoch 451/600
125/125 [==============================] - 0s 928us/step - loss: 0.0198 - val_loss:
0.0011
Epoch 452/600
125/125 [==============================] - 0s 928us/step - loss: 0.0039 - val_loss:
0.0175
Epoch 453/600
125/125 [==============================] - 0s 964us/step - loss: 0.0860 - val_loss:
0.0025
Epoch 454/600
125/125 [==============================] - 0s 932us/step - loss: 0.0023 - val_loss:
0.0020
Epoch 455/600
125/125 [==============================] - 0s 935us/step - loss: 0.0013 - val_loss:
2.4725e-04
Epoch 456/600
125/125 [==============================] - 0s 936us/step - loss: 0.0022 - val_loss:
0.0029
Epoch 457/600
125/125 [==============================] - 0s 940us/step - loss: 0.0043 - val_loss:
0.0020
Epoch 458/600
125/125 [==============================] - 0s 936us/step - loss: 0.0210 - val_loss:
0.0192
Epoch 459/600
125/125 [==============================] - 0s 935us/step - loss: 0.0068 - val_loss:
0.0073
Epoch 460/600
125/125 [==============================] - 0s 940us/step - loss: 0.0393 - val_loss:
0.0014
Epoch 461/600
125/125 [==============================] - 0s 955us/step - loss: 0.0039 - val_loss:
0.0054
Epoch 462/600
125/125 [==============================] - 0s 928us/step - loss: 0.0103 - val_loss:
0.0147
Epoch 463/600
125/125 [==============================] - 0s 941us/step - loss: 0.0069 - val_loss:
0.0015
Epoch 464/600
125/125 [==============================] - 0s 933us/step - loss: 0.0188 - val_loss:
0.0131
Epoch 465/600
125/125 [==============================] - 0s 952us/step - loss: 0.0041 - val_loss:
0.0464
Epoch 466/600
125/125 [==============================] - 0s 936us/step - loss: 0.0531 - val_loss:
3.5544e-04
Epoch 467/600
125/125 [==============================] - 0s 932us/step - loss: 6.0492e-04 - val_lo
```

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ss: 3.4677e-04
Epoch 468/600
125/125 [==============================] - 0s 960us/step - loss: 0.0014 - val_loss:
0.0018
Epoch 469/600
125/125 [==============================] - 0s 932us/step - loss: 0.0042 - val_loss:
0.0023
Epoch 470/600
125/125 [==============================] - 0s 936us/step - loss: 0.0999 - val_loss:
0.0312
Epoch 471/600
125/125 [==============================] - 0s 936us/step - loss: 0.0033 - val_loss:
1.5964e-04
Epoch 472/600
125/125 [==============================] - 0s 945us/step - loss: 2.9700e-04 - val_lo
ss: 2.6574e-04
Epoch 473/600
125/125 [==============================] - 0s 948us/step - loss: 7.7575e-04 - val_lo
ss: 6.8929e-04
Epoch 474/600
125/125 [==============================] - 0s 940us/step - loss: 0.0011 - val_loss:
0.0023
Epoch 475/600
125/125 [==============================] - 0s 928us/step - loss: 7.8021e-04 - val_lo
ss: 1.4895e-04
Epoch 476/600
125/125 [==============================] - 0s 938us/step - loss: 0.0021 - val_loss:
0.0035
Epoch 477/600
125/125 [==============================] - 0s 929us/step - loss: 0.0511 - val_loss:
0.0561
Epoch 478/600
125/125 [==============================] - 0s 931us/step - loss: 0.0098 - val_loss:
0.0018
Epoch 479/600
125/125 [==============================] - 0s 938us/step - loss: 6.1914e-04 - val_lo
ss: 2.6009e-04
Epoch 480/600
125/125 [==============================] - 0s 928us/step - loss: 9.2982e-04 - val_lo
ss: 6.4464e-04
Epoch 481/600
125/125 [==============================] - 0s 929us/step - loss: 0.0119 - val_loss:
0.3680
Epoch 482/600
125/125 [==============================] - 0s 932us/step - loss: 0.0096 - val_loss:
0.0046
Epoch 483/600
125/125 [==============================] - 0s 940us/step - loss: 0.0012 - val_loss:
0.0053
Epoch 484/600
125/125 [==============================] - 0s 956us/step - loss: 0.0127 - val_loss:
2.2083e-04
Epoch 485/600
125/125 [==============================] - 0s 944us/step - loss: 0.0133 - val_loss:
0.0308
Epoch 486/600
```

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125/125 [==============================] - 0s 928us/step - loss: 0.0084 - val_loss:
0.0305
Epoch 487/600
125/125 [==============================] - 0s 941us/step - loss: 0.0077 - val_loss:
0.0042
Epoch 488/600
125/125 [==============================] - 0s 928us/step - loss: 0.0061 - val_loss:
0.0304
Epoch 489/600
125/125 [==============================] - 0s 934us/step - loss: 0.0096 - val_loss:
6.0824e-04
Epoch 490/600
125/125 [==============================] - 0s 936us/step - loss: 0.0091 - val_loss:
0.0213
Epoch 491/600
125/125 [==============================] - 0s 939us/step - loss: 0.0025 - val_loss:
1.6909e-04
Epoch 492/600
125/125 [==============================] - 0s 934us/step - loss: 0.0119 - val_loss:
5.9077e-04
Epoch 493/600
125/125 [==============================] - 0s 932us/step - loss: 0.0021 - val_loss:
0.0026
Epoch 494/600
125/125 [==============================] - 0s 939us/step - loss: 0.0178 - val_loss:
3.3672e-04
Epoch 495/600
125/125 [==============================] - 0s 936us/step - loss: 3.9725e-04 - val_lo
ss: 0.0011
Epoch 496/600
125/125 [==============================] - 0s 938us/step - loss: 0.0059 - val_loss:
2.1595e-04
Epoch 497/600
125/125 [==============================] - 0s 933us/step - loss: 5.6122e-04 - val_lo
ss: 2.1600e-04
Epoch 498/600
125/125 [==============================] - 0s 937us/step - loss: 0.0021 - val_loss:
0.0039
Epoch 499/600
125/125 [==============================] - 0s 940us/step - loss: 0.0041 - val_loss:
0.0284
Epoch 500/600
125/125 [==============================] - 0s 936us/step - loss: 0.0151 - val_loss:
0.0047
Epoch 501/600
125/125 [==============================] - 0s 932us/step - loss: 0.0026 - val_loss:
6.4339e-04
Epoch 502/600
125/125 [==============================] - 0s 940us/step - loss: 0.0013 - val_loss:
0.0021
Epoch 503/600
125/125 [==============================] - 0s 952us/step - loss: 0.0029 - val_loss:
5.1906e-04
Epoch 504/600
125/125 [==============================] - 0s 938us/step - loss: 0.0011 - val_loss:
8.6983e-04
```

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Epoch 505/600
125/125 [==============================] - 0s 940us/step - loss: 0.0043 - val_loss:
2.7660e-04
Epoch 506/600
125/125 [==============================] - 0s 933us/step - loss: 0.0012 - val_loss:
0.0019
Epoch 507/600
125/125 [==============================] - 0s 937us/step - loss: 0.0017 - val_loss:
0.0025
Epoch 508/600
125/125 [==============================] - 0s 938us/step - loss: 0.0056 - val_loss:
0.0021
Epoch 509/600
125/125 [==============================] - 0s 938us/step - loss: 0.0036 - val_loss:
1.0423e-04
Epoch 510/600
125/125 [==============================] - 0s 937us/step - loss: 2.1968e-04 - val_lo
ss: 2.5346e-04
Epoch 511/600
125/125 [==============================] - 0s 933us/step - loss: 3.7399e-04 - val_lo
ss: 2.4650e-04
Epoch 512/600
125/125 [==============================] - 0s 948us/step - loss: 4.4403e-04 - val_lo
ss: 8.5352e-05
Epoch 513/600
125/125 [==============================] - 0s 936us/step - loss: 3.0019e-04 - val_lo
ss: 2.7494e-04
Epoch 514/600
125/125 [==============================] - 0s 936us/step - loss: 6.7965e-04 - val_lo
ss: 1.7937e-04
Epoch 515/600
125/125 [==============================] - 0s 934us/step - loss: 0.0111 - val_loss:
0.0532
Epoch 516/600
125/125 [==============================] - 0s 941us/step - loss: 0.0054 - val_loss:
5.1995e-05
Epoch 517/600
125/125 [==============================] - 0s 956us/step - loss: 6.4062e-05 - val_lo
ss: 6.0552e-05
Epoch 518/600
125/125 [==============================] - 0s 935us/step - loss: 4.9623e-05 - val_lo
ss: 3.4690e-05
Epoch 519/600
125/125 [==============================] - 0s 932us/step - loss: 4.5440e-05 - val_lo
ss: 4.1109e-05
Epoch 520/600
125/125 [==============================] - 0s 932us/step - loss: 5.2832e-05 - val_lo
ss: 4.6548e-05
Epoch 521/600
125/125 [==============================] - 0s 938us/step - loss: 6.1052e-05 - val_lo
ss: 1.0690e-04
Epoch 522/600
125/125 [==============================] - 0s 933us/step - loss: 4.8219e-05 - val_lo
ss: 4.2453e-05
Epoch 523/600
125/125 [==============================] - 0s 933us/step - loss: 4.2221e-05 - val_lo
```

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ss: 3.2718e-05
Epoch 524/600
125/125 [==============================] - 0s 932us/step - loss: 2.9711e-05 - val_lo
ss: 4.4730e-05
Epoch 525/600
125/125 [==============================] - 0s 928us/step - loss: 1.1040e-04 - val_lo
ss: 1.5068e-04
Epoch 526/600
125/125 [==============================] - 0s 932us/step - loss: 5.9255e-05 - val_lo
ss: 5.1879e-05
Epoch 527/600
125/125 [==============================] - 0s 934us/step - loss: 2.0509e-04 - val_lo
ss: 1.7254e-04
Epoch 528/600
125/125 [==============================] - 0s 932us/step - loss: 2.3791e-04 - val_lo
ss: 1.2623e-04
Epoch 529/600
125/125 [==============================] - 0s 943us/step - loss: 4.3132e-04 - val_lo
ss: 0.0022
Epoch 530/600
125/125 [==============================] - 0s 939us/step - loss: 0.0010 - val_loss:
2.5610e-05
Epoch 531/600
125/125 [==============================] - 0s 940us/step - loss: 2.2145e-05 - val_lo
ss: 1.6421e-05
Epoch 532/600
125/125 [==============================] - 0s 936us/step - loss: 5.3305e-04 - val_lo
ss: 1.3686e-04
Epoch 533/600
125/125 [==============================] - 0s 932us/step - loss: 8.5613e-05 - val_lo
ss: 3.2327e-05
Epoch 534/600
125/125 [==============================] - 0s 974us/step - loss: 8.5134e-04 - val_lo
ss: 0.0043
Epoch 535/600
125/125 [==============================] - 0s 947us/step - loss: 0.0010 - val_loss:
0.0016
Epoch 536/600
125/125 [==============================] - 0s 934us/step - loss: 8.2045e-04 - val_lo
ss: 6.3579e-05
Epoch 537/600
125/125 [==============================] - 0s 936us/step - loss: 3.7105e-05 - val_lo
ss: 7.3695e-06
Epoch 538/600
125/125 [==============================] - 0s 943us/step - loss: 6.9550e-05 - val_lo
ss: 7.2372e-05
Epoch 539/600
125/125 [==============================] - 0s 934us/step - loss: 2.7378e-04 - val_lo
ss: 3.8247e-04
Epoch 540/600
125/125 [==============================] - 0s 932us/step - loss: 2.1966 - val_loss:
33.6107
Epoch 541/600
125/125 [==============================] - 0s 934us/step - loss: 2.7234 - val_loss:
0.0538
Epoch 542/600
```

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125/125 [==============================] - 0s 931us/step - loss: 0.0440 - val_loss:
0.0374
Epoch 543/600
125/125 [==============================] - 0s 936us/step - loss: 0.0326 - val_loss:
0.0306
Epoch 544/600
125/125 [==============================] - 0s 944us/step - loss: 0.0242 - val_loss:
0.0222
Epoch 545/600
125/125 [==============================] - 0s 936us/step - loss: 0.0177 - val_loss:
0.0150
Epoch 546/600
125/125 [==============================] - 0s 940us/step - loss: 0.0123 - val_loss:
0.0092
Epoch 547/600
125/125 [==============================] - 0s 930us/step - loss: 0.0078 - val_loss:
0.0057
Epoch 548/600
125/125 [==============================] - 0s 936us/step - loss: 0.0053 - val_loss:
0.0045
Epoch 549/600
125/125 [==============================] - 0s 940us/step - loss: 0.0038 - val_loss:
0.0036
Epoch 550/600
125/125 [==============================] - 0s 936us/step - loss: 0.0029 - val_loss:
0.0027
Epoch 551/600
125/125 [==============================] - 0s 931us/step - loss: 0.0027 - val_loss:
0.0026
Epoch 552/600
125/125 [==============================] - 0s 936us/step - loss: 0.0024 - val_loss:
0.0022
Epoch 553/600
125/125 [==============================] - 0s 936us/step - loss: 0.0023 - val_loss:
0.0022
Epoch 554/600
125/125 [==============================] - 0s 984us/step - loss: 0.0022 - val_loss:
0.0021
Epoch 555/600
125/125 [==============================] - 0s 938us/step - loss: 0.0021 - val_loss:
0.0020
Epoch 556/600
125/125 [==============================] - 0s 944us/step - loss: 0.0020 - val_loss:
0.0021
Epoch 557/600
125/125 [==============================] - 0s 940us/step - loss: 0.0020 - val_loss:
0.0018
Epoch 558/600
125/125 [==============================] - 0s 932us/step - loss: 0.0018 - val_loss:
0.0017
Epoch 559/600
125/125 [==============================] - 0s 941us/step - loss: 0.0017 - val_loss:
0.0016
Epoch 560/600
125/125 [==============================] - 0s 940us/step - loss: 0.0018 - val_loss:
0.0016
```

```
Epoch 561/600
125/125 [==============================] - 0s 938us/step - loss: 0.0018 - val_loss:
0.0018
Epoch 562/600
125/125 [==============================] - 0s 935us/step - loss: 0.0016 - val_loss:
0.0017
Epoch 563/600
125/125 [==============================] - 0s 936us/step - loss: 0.0016 - val_loss:
0.0013
Epoch 564/600
125/125 [==============================] - 0s 935us/step - loss: 0.0016 - val_loss:
0.0013
Epoch 565/600
125/125 [==============================] - 0s 931us/step - loss: 0.0015 - val_loss:
0.0014
Epoch 566/600
125/125 [==============================] - 0s 932us/step - loss: 0.0014 - val_loss:
0.0012
Epoch 567/600
125/125 [==============================] - 0s 936us/step - loss: 0.0016 - val_loss:
0.0026
Epoch 568/600
125/125 [==============================] - 0s 941us/step - loss: 0.0019 - val_loss:
0.0013
Epoch 569/600
125/125 [==============================] - 0s 932us/step - loss: 0.0012 - val_loss:
0.0020
Epoch 570/600
125/125 [==============================] - 0s 956us/step - loss: 0.0011 - val_loss:
0.0013
Epoch 571/600
125/125 [==============================] - 0s 944us/step - loss: 0.0014 - val_loss:
0.0044
Epoch 572/600
125/125 [==============================] - 0s 956us/step - loss: 0.0012 - val_loss:
0.0010
Epoch 573/600
125/125 [==============================] - 0s 940us/step - loss: 0.0010 - val_loss:
8.0223e-04
Epoch 574/600
125/125 [==============================] - 0s 940us/step - loss: 0.0011 - val_loss:
0.0013
Epoch 575/600
125/125 [==============================] - 0s 936us/step - loss: 0.0017 - val_loss:
0.0012
Epoch 576/600
125/125 [==============================] - 0s 936us/step - loss: 0.0013 - val_loss:
6.7772e-04
Epoch 577/600
125/125 [==============================] - 0s 936us/step - loss: 9.6664e-04 - val_lo
ss: 7.8066e-04
Epoch 578/600
125/125 [==============================] - 0s 932us/step - loss: 0.0013 - val_loss:
5.0716e-04
Epoch 579/600
125/125 [==============================] - 0s 938us/step - loss: 0.0023 - val_loss:
```

```
0.0027
Epoch 580/600
125/125 [==============================] - 0s 941us/step - loss: 9.1793e-04 - val_lo
ss: 0.0034
Epoch 581/600
125/125 [==============================] - 0s 948us/step - loss: 0.0021 - val_loss:
0.0034
Epoch 582/600
125/125 [==============================] - 0s 943us/step - loss: 0.0017 - val_loss:
7.4119e-04
Epoch 583/600
125/125 [==============================] - 0s 936us/step - loss: 0.0020 - val_loss:
0.0099
Epoch 584/600
125/125 [==============================] - 0s 973us/step - loss: 0.0037 - val_loss:
0.0012
Epoch 585/600
125/125 [==============================] - 0s 940us/step - loss: 0.0032 - val_loss:
6.5049e-04
Epoch 586/600
125/125 [==============================] - 0s 937us/step - loss: 9.5985e-04 - val_lo
ss: 0.0020
Epoch 587/600
125/125 [==============================] - 0s 943us/step - loss: 0.0012 - val_loss:
0.0012
Epoch 588/600
125/125 [==============================] - 0s 944us/step - loss: 9.1598e-04 - val_lo
ss: 8.0035e-04
Epoch 589/600
125/125 [==============================] - 0s 936us/step - loss: 5.9768e-04 - val_lo
ss: 6.8720e-04
Epoch 590/600
125/125 [==============================] - 0s 936us/step - loss: 7.4930e-04 - val_lo
ss: 1.6684e-04
Epoch 591/600
125/125 [==============================] - 0s 932us/step - loss: 0.0014 - val_loss:
2.0361e-04
Epoch 592/600
125/125 [==============================] - 0s 935us/step - loss: 0.0045 - val_loss:
1.8657e-04
Epoch 593/600
125/125 [==============================] - 0s 932us/step - loss: 3.2649e-04 - val_lo
ss: 1.4808e-04
Epoch 594/600
125/125 [==============================] - 0s 943us/step - loss: 9.7224e-04 - val_lo
ss: 0.0034
Epoch 595/600
125/125 [==============================] - 0s 936us/step - loss: 0.0016 - val_loss:
0.0037
Epoch 596/600
125/125 [==============================] - 0s 932us/step - loss: 7.6717e-04 - val_lo
ss: 2.3268e-04
Epoch 597/600
125/125 [==============================] - 0s 936us/step - loss: 0.0011 - val_loss:
0.0017
Epoch 598/600
```

```
125/125 [==============================] - 0s 967us/step - loss: 0.0019 - val_loss:
1.1339e-04
Epoch 599/600
125/125 [==============================] - 0s 931us/step - loss: 9.6685e-05 - val_lo
ss: 1.8172e-04
Epoch 600/600
125/125 [==============================] - 0s 930us/step - loss: 4.6671e-05 - val_lo
ss: 1.1370e-05
```

In [ ]:

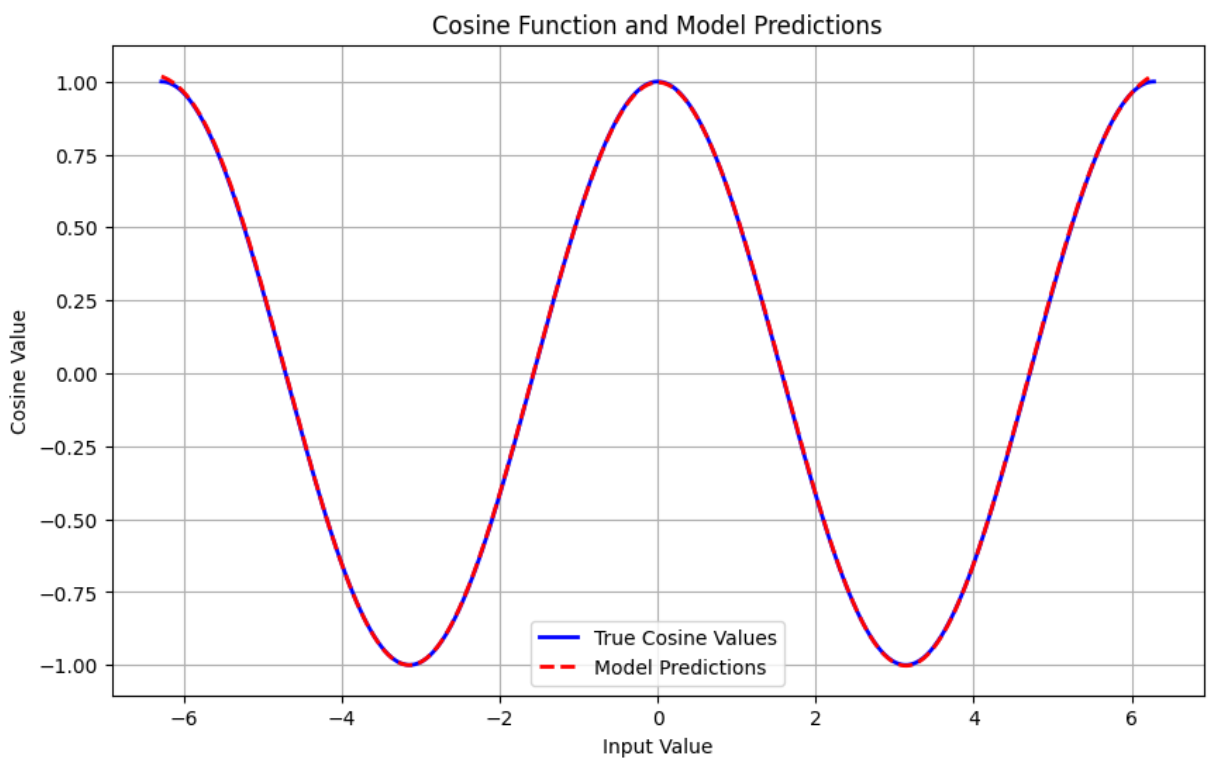
```
val_loss = model.evaluate(X_val, y_val, verbose=0)
print(f"Validation loss: {val_loss}")

import matplotlib.pyplot as plt

num_test_samples = 1000
X_test = np.linspace(lower_bound, upper_bound, num=num_test_samples).reshape(-1, 1)
y_true = np.cos(X_test)
y_pred = model.predict(X_test)

plt.figure(figsize=(10, 6))
plt.plot(X_test, y_true, label='True Cosine Values', color='b', linewidth=2)
plt.plot(X_test, y_pred, label='Model Predictions', color='r', linestyle='--', line
plt.xlabel('Input Value')
plt.ylabel('Cosine Value')
plt.title('Cosine Function and Model Predictions')
plt.legend()
plt.grid()
plt.show()
```

```
Validation loss: 1.1370399079169147e-05
32/32 [==============================] - 0s 527us/step
```



Validation loss: 0.000011