

# LSTM

April 13, 2025

```
[2]: import numpy as np
import os
import sys
import gym
import zipfile
import autograd
import matplotlib.gridspec as gridspec
# Use tf.random.set_seed for TensorFlow 2.0 and above
#from scipy.signal.waveforms import square
import matplotlib.pyplot as plt
from scipy.integrate import solve_ivp
from sklearn.model_selection import train_test_split
import random
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.models import Sequential, model_from_json
from keras.layers import Dense
from keras.layers import Input
from tensorflow.keras import layers
```

```
2025-04-13 02:53:34.201646: I external/local_xla/xla/tsl/cuda/cudart_stub.cc:32]
Could not find cuda drivers on your machine, GPU will not be used.
2025-04-13 02:53:34.204947: I external/local_xla/xla/tsl/cuda/cudart_stub.cc:32]
Could not find cuda drivers on your machine, GPU will not be used.
2025-04-13 02:53:34.213904: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:485] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
2025-04-13 02:53:34.229309: E
external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:8454] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
2025-04-13 02:53:34.233611: E
external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1452] Unable to
register cuBLAS factory: Attempting to register factory for plugin cuBLAS when
one has already been registered
2025-04-13 02:53:34.244703: I tensorflow/core/platform/cpu_feature_guard.cc:210]
This TensorFlow binary is optimized to use available CPU instructions in
```

performance-critical operations.

To enable the following instructions: AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.

2025-04-13 02:53:35.140003: W

tensorflow/compiler/tf2tensorrt/utils/py\_utils.cc:38] TF-TRT Warning: Could not find TensorRT

```
[15]: # @title Hp meristor's state variable:
from IPython.display import display, Math

latex_equation = r"""
\text{State variable:}\quad \frac{dw}{dt} = \mu_v \text{\textit{v}} \cdot \left( \frac{R_{\text{on}}}{D^2} \right) \cdot i(t) \cdot f(w) \quad
\text{Window function:}\quad f(w) = w(1 - w) \quad
\text{state variable in this code is w:}\quad w = \frac{X}{D}
"""
display(Math(latex_equation))
```

State variable:  $\frac{dw}{dt} = \mu_v \cdot \left( \frac{R_{\text{on}}}{D^2} \right) \cdot i(t) \cdot f(w)$

Window function:  $f(w) = w(1 - w)$

state variable in this code is w:  $w = \frac{X}{D}$

```
[8]: import numpy as np
import matplotlib.pyplot as plt
from scipy.integrate import solve_ivp
from sklearn.preprocessing import StandardScaler, MinMaxScaler

# ----- Physical Parameters -----
frequency = 1
A_train = 1.5
W_train = 2 * np.pi * frequency

mu_v = 10**4
D = 60
r_on = 0.1
r_off = 16
r0 = 4
w0 = (r0 - r_off) / (r_on - r_off)

points_per_period = 600

total_points = 10 * points_per_period

# ----- Solving ODE -----
def f(t, w, A, W, mu_v, D, r_on, r_off):
    k = mu_v * (r_on / D**2)
```

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f_w = w * (1 - w)
r = r_on * w + r_off * (1 - w)
I = A * np.sin(W * t) / r
return I * f_w * k

t_all = np.linspace(0, 6, total_points)
sol_all=solve_ivp(f, (0, 6), [w0], t_eval=t_all, args=(A_train, W_train, mu_v, u
    ↪D, r_on, r_off),
    method='RK45', max_step=0.001)

w_all = sol_all.y[0]
v_all = A_train * np.sin(W_train * t_all)
r_all = r_on * w_all + r_off * (1 - w_all)
I_all = v_all / r_all

X_all = np.column_stack([t_all[:-1], w_all[:-1], I_all[:-1]])
y_all = w_all[1:]

# ----- Split Data -----
test_ratio = 0.2
test_size = int(test_ratio * len(X_all))

test_index = np.arange(len(X_all) - test_size, len(X_all))
train_index = np.arange(0, len(X_all) - test_size)

X_train, X_test = X_all[train_index], X_all[test_index]
y_train, y_test = y_all[train_index], y_all[test_index]

print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
plt.figure(figsize=(10, 4))
plt.plot(t_all[:-1], w_all[:-1], label="Original Data", alpha=0.3)
plt.plot(X_train[:, 0], y_train, color='blue', alpha=0.5, label='Train')
plt.plot(X_test[:, 0], y_test, color='red', alpha=0.5, label='Test')
plt.xlabel("Time")
plt.ylabel("w (State Variable)")
plt.title("Train/Test Split for Time-Series Memristor Data")
#plt.grid()
plt.legend()
plt.savefig("rungekutta_train_test.pdf")
plt.show()

```

```

from sklearn.preprocessing import StandardScaler, MinMaxScaler
import numpy as np

# -----
scaler_time = StandardScaler()
X_train[:, 0] = scaler_time.fit_transform(X_train[:, 0].reshape(-1, 1)).
    ↪flatten()
X_test[:, 0] = scaler_time.transform(X_test[:, 0].reshape(-1, 1)).flatten()

scaler_features = MinMaxScaler(feature_range=(-1, 1))
X_train[:, 1:] = scaler_features.fit_transform(X_train[:, 1:])
X_test[:, 1:] = scaler_features.transform(X_test[:, 1:])

scaler_y = MinMaxScaler(feature_range=(-1, 1))
y_train_scaled = scaler_y.fit_transform(y_train.reshape(-1, 1))
y_test_scaled = scaler_y.transform(y_test.reshape(-1, 1))

X_train_scaled = X_train.copy()
X_test_scaled = X_test.copy()

# ----- Create Sequences -----
sequence_length = 10 #
def create_sequences(X, y, sequence_length):
    X_seq, y_seq = [], []
    for i in range(len(X) - sequence_length):
        X_seq.append(X[i:i+sequence_length])
        y_seq.append(y[i+sequence_length])
    return np.array(X_seq), np.array(y_seq).reshape(-1, 1)

X_train_seq, y_train_seq = create_sequences(X_train_scaled, y_train_scaled,
    ↪sequence_length)
X_test_seq, y_test_seq = create_sequences(X_test_scaled, y_test_scaled,
    ↪sequence_length)

print("Mean of X_train_scaled:", np.mean(X_train, axis=0))
print("Std of X_train_scaled:", np.std(X_train, axis=0))
print("Mean of X_test_scaled:", np.mean(X_test, axis=0))
print("Std of X_test_scaled:", np.std(X_test, axis=0))
print("Mean of y_train_scaled:", np.mean(y_train_scaled))
print("Std of y_train_scaled:", np.std(y_train_scaled))

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print("Mean of y_test_scaled:", np.mean(y_test_scaled))
print("Std of y_test_scaled:", np.std(y_test_scaled))

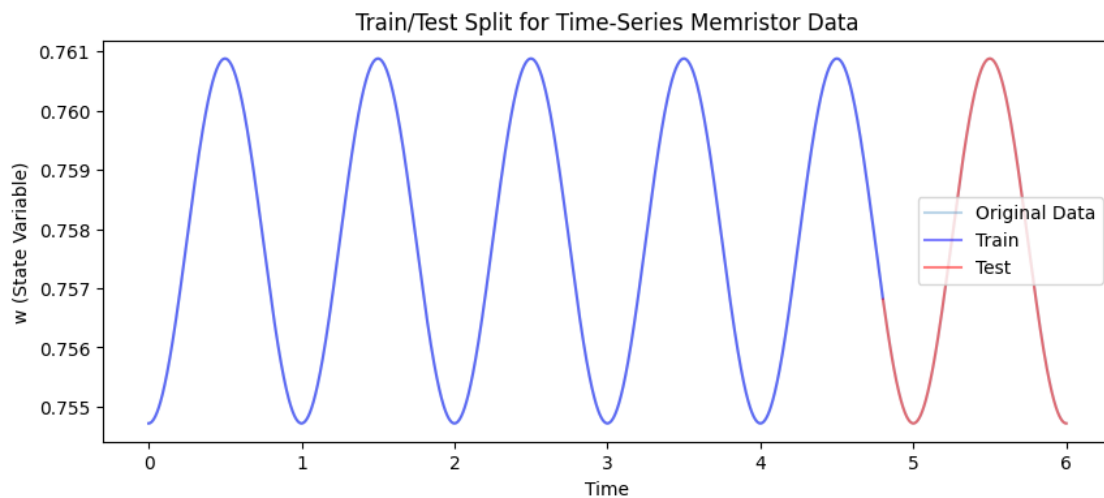
print(f'X_train_seq shape: {X_train_seq.shape}, y_train_seq shape: {y_train_seq.
↪shape}')
print(f'X_test_seq shape: {X_test_seq.shape}, y_test_seq shape: {y_test_seq.
↪shape}')

```

```

(4800, 3)
(1199, 3)
(4800,)
(1199,)

```



```

Mean of X_train_scaled: [-6.65671222e-17  3.04609012e-02  2.26622042e-02]
Std of X_train_scaled: [1.          0.70298873  0.71031816]
Mean of X_test_scaled: [ 2.16470271 -0.12662702 -0.09072466]
Std of X_test_scaled: [0.24979159  0.70958015  0.68660316]
Mean of y_train_scaled: 0.03060324437440435
Std of y_train_scaled: 0.7028492870931501
Mean of y_test_scaled: -0.12719823824974452
Std of y_test_scaled: 0.7100073018388313
X_train_seq shape: (4790, 10, 3), y_train_seq shape: (4790, 1)
X_test_seq shape: (1189, 10, 3), y_test_seq shape: (1189, 1)

```

```

[9]: import numpy as np
import random
import matplotlib.pyplot as plt
import tensorflow as tf

```

```

from tensorflow.keras.layers import Dense, Input, LSTM # Import LSTM here
from tensorflow.keras import Sequential, regularizers
from tensorflow.keras.layers import Dropout

class RNN(tf.keras.Model):
    def __init__(self, **kwargs):
        super().__init__(**kwargs)
        self.RNN = Sequential([
            LSTM(35, return_sequences=True, activation='tanh',
kernel_regularizer=tf.keras.regularizers.l2(1e-4)),
            Dropout(0.06),
            LSTM(39, return_sequences=True, activation='tanh',
kernel_regularizer=tf.keras.regularizers.l2(1e-4)), #
            Dropout(0.06),
            Dense(29, activation='tanh', kernel_regularizer=tf.keras.
kernel_regularizer=tf.keras.regularizers.l2(1e-4)),
            Dense(1,)
        ])

    def call(self, inputs):
        return self.RNN(inputs)

    def build(self, input_shape):
        self.RNN.build(input_shape)
        super().build(input_shape)

rnn = RNN()
rnn.build((None, sequence_length, 3))
rnn.summary()
#####
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint
import tensorflow as tf
import matplotlib.pyplot as plt

# -----

```

Model: "rnn"

Layer (type)	Output Shape	Param #
sequential (Sequential)	?	18,350

Total params: 18,350 (71.68 KB)

Trainable params: 18,350 (71.68 KB)

Non-trainable params: 0 (0.00 B)

```
[10]: NO = 1
Nf = X_train_seq.shape[0]
Nd = y_train_seq.shape[0]

#col_weights = tf.Variable(1.0)    # for ode loss
#u_weights = tf.Variable(1.0)      # for ic loss
#data_weights = tf.Variable(1.5)   # for data loss
#-----
#col_weights = tf.Variable(tf.ones(Nf), dtype=tf.float32)    #weight of ODE
data_weights = tf.Variable(tf.ones(Nd), dtype=tf.float32)    #weight of data
u_weights = tf.Variable(tf.ones(NO), dtype=tf.float32)        ##weight of IC

#optimizer_col_weights = tf.keras.optimizers.Adam(learning_rate=1e-2)
optimizer_data_weights = tf.keras.optimizers.Adam(learning_rate=1e-4)

#print("Shape of col_weights:", col_weights.shape)
print("Shape of ode_res:", data_weights .shape)

print("done")
```

Shape of ode\_res: (4790,)  
done

```
[11]: def compute_loss(X, y_true, mode, u_weights, data_weights):
    X = tf.convert_to_tensor(X, dtype=tf.float32)
    y_true = tf.convert_to_tensor(y_true, dtype=tf.float32)

    with tf.GradientTape(persistent=True) as tape:

        w_pred_sequence = model(X)
        w_pred = w_pred_sequence[:, -1, :]

        I_t = X[:, -1, 0:1]
        w_prev = X[:, -1, 1:2]
        T = X[:, -1, 2:3]

        f_w = w_pred * (1 - w_pred)

        with tf.GradientTape() as g:
```

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        g.watch(T)

        inputs = tf.concat([I_t, w_prev, T], axis=1)
        w_pred_g = model(tf.expand_dims(inputs, axis=1)) # (batch_size, 1, 3)
        dw_dt = g.gradient(w_pred_g, T)

        #ode_res = dw_dt - mu_v * (r_on / D**2) * I_t * f_w

        #ode_loss = tf.reduce_mean(tf.square(col_weights[:, tf.newaxis] *
        ode_res))

        data_loss = tf.reduce_mean(tf.square(data_weights * (w_pred - y_true)))

        #ic_input = tf.convert_to_tensor([[0.0, y_train[0], X_train[0, 2]]],
        dtype=tf.float32)
        ic_input = X[:, 0:1, :]
        ic_pred = model(ic_input)[:, -1, :]

        ic_true = tf.convert_to_tensor(y_train[0], dtype=tf.float32)
        ic_loss = tf.reduce_mean(tf.square(u_weights * (ic_pred - ic_true)))

        total_loss = data_loss + ic_loss

        return total_loss, data_loss, ic_loss

```

```

[14]: from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint
import tensorflow as tf
import matplotlib.pyplot as plt

# ----- Learning Rate Schedule -----
from tensorflow.keras.optimizers.schedules import ExponentialDecay
#earning_rate = tf.keras.optimizers.schedules.ExponentialDecay(
    #initial_learning_rate=1e-3
    #ecay_steps=10000 ,
    #ecay_rate=0.75
#
learning_rate=1e-3

optimizer=tf.keras.optimizers.Adam(learning_rate, clipnorm=1.0)

# ----- ModelCheckpoint Callback -----
checkpoint = ModelCheckpoint(

```



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        'best_model.keras',
        save_best_only=True,
        monitor='val_loss'
    )

# ----- Compile the Model -----
rnn.compile(
    optimizer=optimizer,
    loss='mean_squared_error',
    metrics=['mae']
)

# ----- Training Loop -----
history =rnn.fit(
    X_train_seq,
    y_train_seq,
    validation_data=(X_test_seq, y_test_seq),
    epochs=700,
    batch_size=32,
    callbacks=[checkpoint]
)

```

```

Epoch 1/700
150/150          4s 8ms/step -
loss: 5.8674e-04 - mae: 0.0130 - val_loss: 6.1524e-05 - val_mae: 0.0013
Epoch 2/700
150/150          1s 6ms/step -
loss: 6.0740e-05 - mae: 8.7854e-04 - val_loss: 6.1646e-05 - val_mae: 0.0011
Epoch 3/700
150/150          1s 6ms/step -
loss: 6.0871e-05 - mae: 9.1590e-04 - val_loss: 6.2279e-05 - val_mae: 0.0014
Epoch 4/700
150/150          1s 6ms/step -
loss: 6.0894e-05 - mae: 9.7401e-04 - val_loss: 6.0534e-05 - val_mae: 7.8575e-04
Epoch 5/700
150/150          1s 6ms/step -
loss: 6.1053e-05 - mae: 0.0011 - val_loss: 6.1779e-05 - val_mae: 0.0012
Epoch 6/700
150/150          1s 6ms/step -
loss: 6.2233e-05 - mae: 0.0014 - val_loss: 6.2305e-05 - val_mae: 0.0014
Epoch 7/700
150/150          1s 6ms/step -
loss: 6.3881e-05 - mae: 0.0016 - val_loss: 8.3042e-05 - val_mae: 0.0043
Epoch 8/700
150/150          1s 6ms/step -
loss: 7.2930e-05 - mae: 0.0031 - val_loss: 7.8201e-05 - val_mae: 0.0038
Epoch 9/700
150/150          1s 6ms/step -

```

loss: 6.7380e-05 - mae: 0.0022 - val\_loss: 1.2013e-04 - val\_mae: 0.0071  
 Epoch 10/700  
 150/150 1s 6ms/step -  
 loss: 9.3565e-05 - mae: 0.0048 - val\_loss: 2.0283e-04 - val\_mae: 0.0118  
 Epoch 11/700  
 150/150 1s 6ms/step -  
 loss: 7.8944e-05 - mae: 0.0033 - val\_loss: 1.2121e-04 - val\_mae: 0.0067  
 Epoch 12/700  
 150/150 1s 7ms/step -  
 loss: 7.1031e-05 - mae: 0.0026 - val\_loss: 6.3022e-05 - val\_mae: 0.0018  
 Epoch 13/700  
 150/150 1s 6ms/step -  
 loss: 6.2978e-05 - mae: 0.0016 - val\_loss: 1.8845e-04 - val\_mae: 0.0105  
 Epoch 14/700  
 150/150 1s 6ms/step -  
 loss: 1.4015e-04 - mae: 0.0065 - val\_loss: 6.0881e-05 - val\_mae: 8.5934e-04  
 Epoch 15/700  
 150/150 1s 6ms/step -  
 loss: 6.1252e-05 - mae: 0.0012 - val\_loss: 6.5138e-05 - val\_mae: 0.0023  
 Epoch 16/700  
 150/150 1s 6ms/step -  
 loss: 6.4542e-05 - mae: 0.0020 - val\_loss: 6.6753e-05 - val\_mae: 0.0028  
 Epoch 17/700  
 150/150 1s 6ms/step -  
 loss: 6.3976e-05 - mae: 0.0018 - val\_loss: 6.0616e-05 - val\_mae: 0.0011  
 Epoch 18/700  
 150/150 1s 6ms/step -  
 loss: 7.1943e-05 - mae: 0.0027 - val\_loss: 6.3653e-05 - val\_mae: 0.0018  
 Epoch 19/700  
 150/150 1s 6ms/step -  
 loss: 8.0405e-05 - mae: 0.0037 - val\_loss: 6.2392e-05 - val\_mae: 0.0016  
 Epoch 20/700  
 150/150 1s 6ms/step -  
 loss: 6.7213e-05 - mae: 0.0023 - val\_loss: 6.0579e-05 - val\_mae: 0.0010  
 Epoch 21/700  
 150/150 1s 6ms/step -  
 loss: 7.4869e-05 - mae: 0.0026 - val\_loss: 0.0016 - val\_mae: 0.0341  
 Epoch 22/700  
 150/150 1s 6ms/step -  
 loss: 3.5089e-04 - mae: 0.0095 - val\_loss: 6.1649e-05 - val\_mae: 0.0011  
 Epoch 23/700  
 150/150 1s 6ms/step -  
 loss: 6.1059e-05 - mae: 0.0012 - val\_loss: 6.3273e-05 - val\_mae: 0.0019  
 Epoch 24/700  
 150/150 1s 6ms/step -  
 loss: 6.1656e-05 - mae: 0.0014 - val\_loss: 6.4432e-05 - val\_mae: 0.0022  
 Epoch 25/700  
 150/150 1s 6ms/step -

loss: 6.1178e-05 - mae: 0.0012 - val\_loss: 6.0738e-05 - val\_mae: 9.6585e-04  
 Epoch 26/700  
 150/150 1s 6ms/step -  
 loss: 6.2277e-05 - mae: 0.0015 - val\_loss: 9.1989e-05 - val\_mae: 0.0048  
 Epoch 27/700  
 150/150 1s 6ms/step -  
 loss: 6.6173e-05 - mae: 0.0021 - val\_loss: 7.3245e-05 - val\_mae: 0.0034  
 Epoch 28/700  
 150/150 1s 6ms/step -  
 loss: 6.6880e-05 - mae: 0.0023 - val\_loss: 7.8498e-05 - val\_mae: 0.0041  
 Epoch 29/700  
 150/150 1s 6ms/step -  
 loss: 6.8680e-05 - mae: 0.0024 - val\_loss: 6.2406e-05 - val\_mae: 0.0016  
 Epoch 30/700  
 150/150 1s 6ms/step -  
 loss: 7.7038e-05 - mae: 0.0028 - val\_loss: 9.8989e-05 - val\_mae: 0.0060  
 Epoch 31/700  
 150/150 1s 6ms/step -  
 loss: 6.7348e-05 - mae: 0.0023 - val\_loss: 6.0161e-05 - val\_mae: 9.5418e-04  
 Epoch 32/700  
 150/150 1s 8ms/step -  
 loss: 6.1464e-05 - mae: 0.0014 - val\_loss: 6.8007e-05 - val\_mae: 0.0029  
 Epoch 33/700  
 150/150 1s 6ms/step -  
 loss: 6.4140e-05 - mae: 0.0019 - val\_loss: 6.2253e-05 - val\_mae: 0.0017  
 Epoch 34/700  
 150/150 1s 6ms/step -  
 loss: 7.3308e-05 - mae: 0.0025 - val\_loss: 8.2610e-05 - val\_mae: 0.0041  
 Epoch 35/700  
 150/150 1s 6ms/step -  
 loss: 7.2546e-05 - mae: 0.0030 - val\_loss: 6.2782e-05 - val\_mae: 0.0020  
 Epoch 36/700  
 150/150 1s 6ms/step -  
 loss: 6.5186e-05 - mae: 0.0020 - val\_loss: 8.3827e-05 - val\_mae: 0.0043  
 Epoch 37/700  
 150/150 1s 6ms/step -  
 loss: 6.5318e-05 - mae: 0.0022 - val\_loss: 7.2132e-05 - val\_mae: 0.0034  
 Epoch 38/700  
 150/150 1s 6ms/step -  
 loss: 7.1668e-05 - mae: 0.0029 - val\_loss: 7.1202e-05 - val\_mae: 0.0032  
 Epoch 39/700  
 150/150 1s 6ms/step -  
 loss: 9.2924e-05 - mae: 0.0047 - val\_loss: 7.6208e-05 - val\_mae: 0.0039  
 Epoch 40/700  
 150/150 1s 6ms/step -  
 loss: 6.7596e-05 - mae: 0.0024 - val\_loss: 6.1669e-05 - val\_mae: 0.0016  
 Epoch 41/700  
 150/150 1s 6ms/step -

loss: 6.4600e-05 - mae: 0.0019 - val\_loss: 7.1131e-05 - val\_mae: 0.0031  
 Epoch 42/700  
 150/150 1s 6ms/step -  
 loss: 7.5643e-05 - mae: 0.0034 - val\_loss: 8.2467e-05 - val\_mae: 0.0041  
 Epoch 43/700  
 150/150 1s 6ms/step -  
 loss: 6.8871e-05 - mae: 0.0027 - val\_loss: 1.3425e-04 - val\_mae: 0.0075  
 Epoch 44/700  
 150/150 1s 6ms/step -  
 loss: 1.3221e-04 - mae: 0.0065 - val\_loss: 6.3373e-05 - val\_mae: 0.0019  
 Epoch 45/700  
 150/150 1s 6ms/step -  
 loss: 6.3690e-05 - mae: 0.0019 - val\_loss: 6.7594e-05 - val\_mae: 0.0029  
 Epoch 46/700  
 150/150 1s 6ms/step -  
 loss: 6.9892e-05 - mae: 0.0028 - val\_loss: 8.9529e-05 - val\_mae: 0.0047  
 Epoch 47/700  
 150/150 1s 6ms/step -  
 loss: 7.6102e-05 - mae: 0.0035 - val\_loss: 6.2023e-05 - val\_mae: 0.0017  
 Epoch 48/700  
 150/150 1s 6ms/step -  
 loss: 6.6795e-05 - mae: 0.0023 - val\_loss: 6.1644e-05 - val\_mae: 0.0015  
 Epoch 49/700  
 150/150 1s 6ms/step -  
 loss: 6.2708e-05 - mae: 0.0017 - val\_loss: 6.2493e-05 - val\_mae: 0.0017  
 Epoch 50/700  
 150/150 1s 6ms/step -  
 loss: 6.3052e-05 - mae: 0.0018 - val\_loss: 6.5429e-05 - val\_mae: 0.0023  
 Epoch 51/700  
 150/150 1s 6ms/step -  
 loss: 7.1209e-05 - mae: 0.0029 - val\_loss: 6.0876e-05 - val\_mae: 0.0013  
 Epoch 52/700  
 150/150 1s 7ms/step -  
 loss: 7.2697e-05 - mae: 0.0026 - val\_loss: 6.5053e-05 - val\_mae: 0.0022  
 Epoch 53/700  
 150/150 1s 7ms/step -  
 loss: 1.0198e-04 - mae: 0.0052 - val\_loss: 6.2714e-05 - val\_mae: 0.0021  
 Epoch 54/700  
 150/150 1s 6ms/step -  
 loss: 6.0475e-05 - mae: 0.0012 - val\_loss: 6.2384e-05 - val\_mae: 0.0018  
 Epoch 55/700  
 150/150 1s 6ms/step -  
 loss: 6.2988e-05 - mae: 0.0018 - val\_loss: 1.3006e-04 - val\_mae: 0.0082  
 Epoch 56/700  
 150/150 1s 6ms/step -  
 loss: 6.5674e-05 - mae: 0.0020 - val\_loss: 7.1259e-05 - val\_mae: 0.0033  
 Epoch 57/700

150/150                    1s 7ms/step -  
 loss: 6.7939e-05 - mae: 0.0026 - val\_loss: 1.1048e-04 - val\_mae: 0.0062  
 Epoch 58/700  
 150/150                    1s 7ms/step -  
 loss: 9.2332e-05 - mae: 0.0047 - val\_loss: 6.9894e-05 - val\_mae: 0.0031  
 Epoch 59/700  
 150/150                    1s 6ms/step -  
 loss: 6.1086e-05 - mae: 0.0014 - val\_loss: 6.5913e-05 - val\_mae: 0.0027  
 Epoch 60/700  
 150/150                    1s 8ms/step -  
 loss: 6.2606e-05 - mae: 0.0018 - val\_loss: 6.8631e-05 - val\_mae: 0.0032  
 Epoch 61/700  
 150/150                    1s 8ms/step -  
 loss: 7.7437e-05 - mae: 0.0031 - val\_loss: 1.4059e-04 - val\_mae: 0.0085  
 Epoch 62/700  
 150/150                    1s 7ms/step -  
 loss: 1.2559e-04 - mae: 0.0061 - val\_loss: 6.1546e-05 - val\_mae: 0.0016  
 Epoch 63/700  
 150/150                    1s 6ms/step -  
 loss: 5.9884e-05 - mae: 0.0011 - val\_loss: 6.5725e-05 - val\_mae: 0.0024  
 Epoch 64/700  
 150/150                    1s 5ms/step -  
 loss: 6.1952e-05 - mae: 0.0017 - val\_loss: 6.0896e-05 - val\_mae: 0.0011  
 Epoch 65/700  
 150/150                    1s 6ms/step -  
 loss: 6.0476e-05 - mae: 0.0013 - val\_loss: 6.0368e-05 - val\_mae: 0.0013  
 Epoch 66/700  
 150/150                    1s 6ms/step -  
 loss: 6.2378e-05 - mae: 0.0017 - val\_loss: 6.8335e-05 - val\_mae: 0.0027  
 Epoch 67/700  
 150/150                    1s 5ms/step -  
 loss: 6.5835e-05 - mae: 0.0023 - val\_loss: 6.1231e-05 - val\_mae: 0.0016  
 Epoch 68/700  
 150/150                    1s 6ms/step -  
 loss: 9.9168e-05 - mae: 0.0043 - val\_loss: 9.5908e-05 - val\_mae: 0.0057  
 Epoch 69/700  
 150/150                    1s 6ms/step -  
 loss: 6.9263e-05 - mae: 0.0026 - val\_loss: 6.0845e-05 - val\_mae: 0.0015  
 Epoch 70/700  
 150/150                    1s 6ms/step -  
 loss: 6.0702e-05 - mae: 0.0014 - val\_loss: 6.1442e-05 - val\_mae: 0.0014  
 Epoch 71/700  
 150/150                    1s 6ms/step -  
 loss: 6.0621e-05 - mae: 0.0013 - val\_loss: 6.0038e-05 - val\_mae: 0.0012  
 Epoch 72/700  
 150/150                    1s 6ms/step -  
 loss: 7.1142e-05 - mae: 0.0027 - val\_loss: 6.0586e-05 - val\_mae: 0.0012  
 Epoch 73/700

150/150                    1s 6ms/step -  
 loss: 6.1678e-05 - mae: 0.0016 - val\_loss: 6.3576e-05 - val\_mae: 0.0024  
 Epoch 74/700  
 150/150                    1s 5ms/step -  
 loss: 6.7527e-05 - mae: 0.0027 - val\_loss: 6.7005e-05 - val\_mae: 0.0027  
 Epoch 75/700  
 150/150                    1s 6ms/step -  
 loss: 7.8476e-05 - mae: 0.0035 - val\_loss: 8.8227e-05 - val\_mae: 0.0045  
 Epoch 76/700  
 150/150                    1s 6ms/step -  
 loss: 1.0616e-04 - mae: 0.0053 - val\_loss: 6.0933e-05 - val\_mae: 0.0015  
 Epoch 77/700  
 150/150                    1s 5ms/step -  
 loss: 6.7139e-05 - mae: 0.0026 - val\_loss: 5.9271e-05 - val\_mae: 0.0010  
 Epoch 78/700  
 150/150                    1s 5ms/step -  
 loss: 6.0538e-05 - mae: 0.0014 - val\_loss: 6.2820e-05 - val\_mae: 0.0020  
 Epoch 79/700  
 150/150                    1s 5ms/step -  
 loss: 6.9832e-05 - mae: 0.0026 - val\_loss: 7.0266e-05 - val\_mae: 0.0035  
 Epoch 80/700  
 150/150                    1s 6ms/step -  
 loss: 1.0574e-04 - mae: 0.0052 - val\_loss: 1.1110e-04 - val\_mae: 0.0071  
 Epoch 81/700  
 150/150                    1s 6ms/step -  
 loss: 8.6519e-05 - mae: 0.0037 - val\_loss: 6.0503e-05 - val\_mae: 0.0011  
 Epoch 82/700  
 150/150                    1s 6ms/step -  
 loss: 6.0072e-05 - mae: 0.0013 - val\_loss: 6.3581e-05 - val\_mae: 0.0021  
 Epoch 83/700  
 150/150                    1s 6ms/step -  
 loss: 6.0327e-05 - mae: 0.0013 - val\_loss: 6.2443e-05 - val\_mae: 0.0020  
 Epoch 84/700  
 150/150                    1s 6ms/step -  
 loss: 6.0690e-05 - mae: 0.0014 - val\_loss: 6.1769e-05 - val\_mae: 0.0018  
 Epoch 85/700  
 150/150                    1s 6ms/step -  
 loss: 6.3239e-05 - mae: 0.0019 - val\_loss: 6.5073e-05 - val\_mae: 0.0025  
 Epoch 86/700  
 150/150                    1s 7ms/step -  
 loss: 6.1798e-05 - mae: 0.0018 - val\_loss: 7.1857e-05 - val\_mae: 0.0034  
 Epoch 87/700  
 150/150                    1s 6ms/step -  
 loss: 6.6823e-05 - mae: 0.0024 - val\_loss: 7.4902e-05 - val\_mae: 0.0035  
 Epoch 88/700  
 150/150                    1s 6ms/step -  
 loss: 1.9695e-04 - mae: 0.0094 - val\_loss: 6.2108e-05 - val\_mae: 0.0020  
 Epoch 89/700

150/150                    1s 7ms/step -  
 loss: 6.7502e-05 - mae: 0.0022 - val\_loss: 6.1939e-05 - val\_mae: 0.0020  
 Epoch 90/700  
 150/150                    1s 6ms/step -  
 loss: 5.9719e-05 - mae: 0.0012 - val\_loss: 7.0228e-05 - val\_mae: 0.0036  
 Epoch 91/700  
 150/150                    1s 6ms/step -  
 loss: 6.1859e-05 - mae: 0.0017 - val\_loss: 6.8332e-05 - val\_mae: 0.0027  
 Epoch 92/700  
 150/150                    1s 6ms/step -  
 loss: 6.2465e-05 - mae: 0.0019 - val\_loss: 6.0596e-05 - val\_mae: 0.0016  
 Epoch 93/700  
 150/150                    1s 6ms/step -  
 loss: 6.3609e-05 - mae: 0.0020 - val\_loss: 2.6829e-04 - val\_mae: 0.0121  
 Epoch 94/700  
 150/150                    1s 6ms/step -  
 loss: 1.2973e-04 - mae: 0.0066 - val\_loss: 6.3895e-05 - val\_mae: 0.0022  
 Epoch 95/700  
 150/150                    1s 6ms/step -  
 loss: 6.2319e-05 - mae: 0.0019 - val\_loss: 8.3221e-05 - val\_mae: 0.0048  
 Epoch 96/700  
 150/150                    1s 7ms/step -  
 loss: 6.0822e-05 - mae: 0.0014 - val\_loss: 6.1108e-05 - val\_mae: 0.0017  
 Epoch 97/700  
 150/150                    1s 6ms/step -  
 loss: 6.3340e-05 - mae: 0.0018 - val\_loss: 7.4245e-05 - val\_mae: 0.0040  
 Epoch 98/700  
 150/150                    1s 6ms/step -  
 loss: 6.8931e-05 - mae: 0.0027 - val\_loss: 7.1972e-05 - val\_mae: 0.0035  
 Epoch 99/700  
 150/150                    1s 6ms/step -  
 loss: 6.0630e-05 - mae: 0.0015 - val\_loss: 7.1691e-05 - val\_mae: 0.0032  
 Epoch 100/700  
 150/150                    1s 6ms/step -  
 loss: 1.0366e-04 - mae: 0.0054 - val\_loss: 6.7294e-05 - val\_mae: 0.0026  
 Epoch 101/700  
 150/150                    1s 6ms/step -  
 loss: 6.1038e-05 - mae: 0.0016 - val\_loss: 6.0779e-05 - val\_mae: 0.0012  
 Epoch 102/700  
 150/150                    1s 5ms/step -  
 loss: 6.1245e-05 - mae: 0.0017 - val\_loss: 1.4014e-04 - val\_mae: 0.0085  
 Epoch 103/700  
 150/150                    1s 7ms/step -  
 loss: 1.4180e-04 - mae: 0.0065 - val\_loss: 6.3688e-05 - val\_mae: 0.0020  
 Epoch 104/700  
 150/150                    1s 6ms/step -  
 loss: 6.2482e-05 - mae: 0.0020 - val\_loss: 7.1827e-05 - val\_mae: 0.0036

Epoch 105/700  
150/150 1s 6ms/step -  
loss: 6.0634e-05 - mae: 0.0015 - val\_loss: 5.9180e-05 - val\_mae: 0.0012

Epoch 106/700  
150/150 1s 6ms/step -  
loss: 6.0897e-05 - mae: 0.0016 - val\_loss: 6.0950e-05 - val\_mae: 0.0017

Epoch 107/700  
150/150 1s 6ms/step -  
loss: 6.4914e-05 - mae: 0.0023 - val\_loss: 9.8485e-05 - val\_mae: 0.0057

Epoch 108/700  
150/150 1s 5ms/step -  
loss: 9.7214e-05 - mae: 0.0051 - val\_loss: 5.8958e-05 - val\_mae: 0.0011

Epoch 109/700  
150/150 1s 6ms/step -  
loss: 7.2928e-05 - mae: 0.0030 - val\_loss: 6.3341e-05 - val\_mae: 0.0021

Epoch 110/700  
150/150 1s 6ms/step -  
loss: 6.1133e-05 - mae: 0.0017 - val\_loss: 1.0765e-04 - val\_mae: 0.0067

Epoch 111/700  
150/150 1s 6ms/step -  
loss: 1.0491e-04 - mae: 0.0051 - val\_loss: 6.6283e-05 - val\_mae: 0.0027

Epoch 112/700  
150/150 1s 6ms/step -  
loss: 6.2461e-05 - mae: 0.0020 - val\_loss: 5.8777e-05 - val\_mae: 0.0010

Epoch 113/700  
150/150 1s 5ms/step -  
loss: 5.9840e-05 - mae: 0.0014 - val\_loss: 5.9881e-05 - val\_mae: 0.0013

Epoch 114/700  
150/150 1s 5ms/step -  
loss: 6.4312e-05 - mae: 0.0022 - val\_loss: 7.1255e-05 - val\_mae: 0.0036

Epoch 115/700  
150/150 1s 6ms/step -  
loss: 7.1795e-05 - mae: 0.0031 - val\_loss: 1.1269e-04 - val\_mae: 0.0063

Epoch 116/700  
150/150 1s 7ms/step -  
loss: 9.9844e-05 - mae: 0.0053 - val\_loss: 7.6796e-05 - val\_mae: 0.0043

Epoch 117/700  
150/150 1s 6ms/step -  
loss: 6.2703e-05 - mae: 0.0020 - val\_loss: 6.5503e-05 - val\_mae: 0.0028

Epoch 118/700  
150/150 1s 7ms/step -  
loss: 6.7660e-05 - mae: 0.0025 - val\_loss: 5.9650e-05 - val\_mae: 0.0013

Epoch 119/700  
150/150 2s 11ms/step -  
loss: 6.3311e-05 - mae: 0.0020 - val\_loss: 6.4774e-05 - val\_mae: 0.0023

Epoch 120/700  
150/150 1s 6ms/step -  
loss: 6.8434e-05 - mae: 0.0026 - val\_loss: 8.2222e-05 - val\_mae: 0.0045



Epoch 121/700  
150/150 1s 5ms/step -  
loss: 7.0795e-05 - mae: 0.0029 - val\_loss: 5.9135e-05 - val\_mae: 0.0011

Epoch 122/700  
150/150 1s 5ms/step -  
loss: 6.8434e-05 - mae: 0.0028 - val\_loss: 7.7711e-05 - val\_mae: 0.0040

Epoch 123/700  
150/150 1s 5ms/step -  
loss: 6.3827e-05 - mae: 0.0023 - val\_loss: 8.3800e-05 - val\_mae: 0.0051

Epoch 124/700  
150/150 1s 5ms/step -  
loss: 9.7129e-05 - mae: 0.0045 - val\_loss: 6.1725e-05 - val\_mae: 0.0022

Epoch 125/700  
150/150 1s 5ms/step -  
loss: 5.9596e-05 - mae: 0.0014 - val\_loss: 5.9194e-05 - val\_mae: 0.0015

Epoch 126/700  
150/150 1s 5ms/step -  
loss: 6.2424e-05 - mae: 0.0017 - val\_loss: 7.4001e-05 - val\_mae: 0.0041

Epoch 127/700  
150/150 1s 5ms/step -  
loss: 6.2769e-05 - mae: 0.0020 - val\_loss: 6.5042e-05 - val\_mae: 0.0025

Epoch 128/700  
150/150 1s 5ms/step -  
loss: 6.9861e-05 - mae: 0.0027 - val\_loss: 7.8397e-05 - val\_mae: 0.0039

Epoch 129/700  
150/150 1s 5ms/step -  
loss: 8.3498e-05 - mae: 0.0041 - val\_loss: 6.0307e-05 - val\_mae: 0.0014

Epoch 130/700  
150/150 1s 5ms/step -  
loss: 6.0333e-05 - mae: 0.0016 - val\_loss: 5.9913e-05 - val\_mae: 0.0017

Epoch 131/700  
150/150 1s 5ms/step -  
loss: 1.0540e-04 - mae: 0.0049 - val\_loss: 8.5130e-05 - val\_mae: 0.0051

Epoch 132/700  
150/150 1s 5ms/step -  
loss: 6.7670e-05 - mae: 0.0025 - val\_loss: 5.8486e-05 - val\_mae: 0.0011

Epoch 133/700  
150/150 1s 5ms/step -  
loss: 5.8965e-05 - mae: 0.0012 - val\_loss: 6.1198e-05 - val\_mae: 0.0018

Epoch 134/700  
150/150 1s 5ms/step -  
loss: 6.0222e-05 - mae: 0.0016 - val\_loss: 5.8573e-05 - val\_mae: 0.0012

Epoch 135/700  
150/150 1s 5ms/step -  
loss: 6.0171e-05 - mae: 0.0016 - val\_loss: 6.9028e-05 - val\_mae: 0.0031

Epoch 136/700  
150/150 1s 5ms/step -  
loss: 6.4220e-05 - mae: 0.0022 - val\_loss: 6.1775e-05 - val\_mae: 0.0020

Epoch 137/700  
150/150 1s 5ms/step -  
loss: 8.8722e-05 - mae: 0.0046 - val\_loss: 1.4240e-04 - val\_mae: 0.0081  
Epoch 138/700  
150/150 1s 6ms/step -  
loss: 7.3506e-05 - mae: 0.0030 - val\_loss: 5.8556e-05 - val\_mae: 0.0012  
Epoch 139/700  
150/150 1s 5ms/step -  
loss: 6.0917e-05 - mae: 0.0017 - val\_loss: 6.2006e-05 - val\_mae: 0.0021  
Epoch 140/700  
150/150 1s 5ms/step -  
loss: 6.2619e-05 - mae: 0.0020 - val\_loss: 7.0984e-05 - val\_mae: 0.0031  
Epoch 141/700  
150/150 1s 5ms/step -  
loss: 1.3182e-04 - mae: 0.0068 - val\_loss: 7.1686e-05 - val\_mae: 0.0033  
Epoch 142/700  
150/150 1s 5ms/step -  
loss: 6.1940e-05 - mae: 0.0019 - val\_loss: 5.9065e-05 - val\_mae: 0.0013  
Epoch 143/700  
150/150 1s 5ms/step -  
loss: 5.8482e-05 - mae: 0.0011 - val\_loss: 5.9078e-05 - val\_mae: 0.0012  
Epoch 144/700  
150/150 1s 5ms/step -  
loss: 6.1790e-05 - mae: 0.0019 - val\_loss: 5.8211e-05 - val\_mae: 0.0010  
Epoch 145/700  
150/150 1s 5ms/step -  
loss: 6.5634e-05 - mae: 0.0024 - val\_loss: 6.4211e-05 - val\_mae: 0.0024  
Epoch 146/700  
150/150 1s 5ms/step -  
loss: 9.6692e-05 - mae: 0.0048 - val\_loss: 5.8249e-05 - val\_mae: 0.0010  
Epoch 147/700  
150/150 1s 5ms/step -  
loss: 6.3029e-05 - mae: 0.0020 - val\_loss: 6.5176e-05 - val\_mae: 0.0025  
Epoch 148/700  
150/150 1s 5ms/step -  
loss: 6.5434e-05 - mae: 0.0025 - val\_loss: 7.2999e-05 - val\_mae: 0.0039  
Epoch 149/700  
150/150 1s 5ms/step -  
loss: 7.1955e-05 - mae: 0.0031 - val\_loss: 5.8907e-05 - val\_mae: 0.0015  
Epoch 150/700  
150/150 1s 5ms/step -  
loss: 7.1172e-05 - mae: 0.0028 - val\_loss: 6.6040e-05 - val\_mae: 0.0026  
Epoch 151/700  
150/150 1s 5ms/step -  
loss: 6.8244e-05 - mae: 0.0025 - val\_loss: 6.5034e-05 - val\_mae: 0.0025  
Epoch 152/700  
150/150 1s 5ms/step -

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loss: 6.7666e-05 - mae: 0.0026 - val_loss: 2.8600e-04 - val_mae: 0.0136
Epoch 153/700
150/150          1s 5ms/step -
loss: 1.1206e-04 - mae: 0.0057 - val_loss: 5.8962e-05 - val_mae: 0.0014
Epoch 154/700
150/150          1s 5ms/step -
loss: 6.3468e-05 - mae: 0.0022 - val_loss: 7.6769e-05 - val_mae: 0.0044
Epoch 155/700
150/150          1s 6ms/step -
loss: 6.1362e-05 - mae: 0.0019 - val_loss: 6.2121e-05 - val_mae: 0.0023
Epoch 156/700
150/150          1s 6ms/step -
loss: 5.9881e-05 - mae: 0.0016 - val_loss: 6.3723e-05 - val_mae: 0.0027
Epoch 157/700
150/150          1s 5ms/step -
loss: 6.0132e-05 - mae: 0.0017 - val_loss: 1.2175e-04 - val_mae: 0.0079
Epoch 158/700
150/150          1s 7ms/step -
loss: 6.9238e-05 - mae: 0.0030 - val_loss: 8.2942e-05 - val_mae: 0.0045
Epoch 159/700
150/150          1s 5ms/step -
loss: 1.1140e-04 - mae: 0.0057 - val_loss: 5.9117e-05 - val_mae: 0.0016
Epoch 160/700
150/150          1s 9ms/step -
loss: 6.5092e-05 - mae: 0.0024 - val_loss: 6.3545e-05 - val_mae: 0.0028
Epoch 161/700
150/150          1s 6ms/step -
loss: 6.8488e-05 - mae: 0.0028 - val_loss: 5.8440e-05 - val_mae: 0.0012
Epoch 162/700
150/150          1s 6ms/step -
loss: 6.2277e-05 - mae: 0.0020 - val_loss: 6.4355e-05 - val_mae: 0.0026
Epoch 163/700
150/150          1s 5ms/step -
loss: 8.9903e-05 - mae: 0.0037 - val_loss: 7.6683e-05 - val_mae: 0.0038
Epoch 164/700
150/150          1s 5ms/step -
loss: 6.5653e-05 - mae: 0.0026 - val_loss: 5.9838e-05 - val_mae: 0.0016
Epoch 165/700
150/150          1s 5ms/step -
loss: 5.7953e-05 - mae: 0.0011 - val_loss: 6.2064e-05 - val_mae: 0.0020
Epoch 166/700
150/150          1s 5ms/step -
loss: 6.0251e-05 - mae: 0.0017 - val_loss: 5.7629e-05 - val_mae: 9.6420e-04
Epoch 167/700
150/150          1s 5ms/step -
loss: 7.0240e-05 - mae: 0.0029 - val_loss: 5.8334e-05 - val_mae: 0.0014
Epoch 168/700
150/150          1s 5ms/step -

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loss: 5.9503e-05 - mae: 0.0014 - val\_loss: 7.2593e-05 - val\_mae: 0.0038  
 Epoch 169/700  
 150/150 1s 5ms/step -  
 loss: 7.5172e-05 - mae: 0.0033 - val\_loss: 7.8946e-05 - val\_mae: 0.0042  
 Epoch 170/700  
 150/150 1s 5ms/step -  
 loss: 1.0000e-04 - mae: 0.0049 - val\_loss: 7.9910e-05 - val\_mae: 0.0041  
 Epoch 171/700  
 150/150 1s 5ms/step -  
 loss: 6.4995e-05 - mae: 0.0024 - val\_loss: 5.8056e-05 - val\_mae: 0.0012  
 Epoch 172/700  
 150/150 1s 5ms/step -  
 loss: 5.8891e-05 - mae: 0.0014 - val\_loss: 9.7296e-05 - val\_mae: 0.0055  
 Epoch 173/700  
 150/150 1s 5ms/step -  
 loss: 1.1008e-04 - mae: 0.0056 - val\_loss: 6.4753e-05 - val\_mae: 0.0026  
 Epoch 174/700  
 150/150 1s 6ms/step -  
 loss: 6.3493e-05 - mae: 0.0023 - val\_loss: 6.1107e-05 - val\_mae: 0.0022  
 Epoch 175/700  
 150/150 1s 7ms/step -  
 loss: 5.9621e-05 - mae: 0.0016 - val\_loss: 7.6370e-05 - val\_mae: 0.0044  
 Epoch 176/700  
 150/150 1s 5ms/step -  
 loss: 6.4637e-05 - mae: 0.0025 - val\_loss: 6.9829e-05 - val\_mae: 0.0032  
 Epoch 177/700  
 150/150 1s 5ms/step -  
 loss: 6.3836e-05 - mae: 0.0023 - val\_loss: 6.2654e-05 - val\_mae: 0.0022  
 Epoch 178/700  
 150/150 1s 5ms/step -  
 loss: 7.1701e-05 - mae: 0.0029 - val\_loss: 2.3472e-04 - val\_mae: 0.0132  
 Epoch 179/700  
 150/150 1s 5ms/step -  
 loss: 1.5043e-04 - mae: 0.0077 - val\_loss: 6.0259e-05 - val\_mae: 0.0017  
 Epoch 180/700  
 150/150 1s 5ms/step -  
 loss: 7.3761e-05 - mae: 0.0031 - val\_loss: 5.7558e-05 - val\_mae: 0.0010  
 Epoch 181/700  
 150/150 1s 6ms/step -  
 loss: 5.8538e-05 - mae: 0.0013 - val\_loss: 5.9402e-05 - val\_mae: 0.0017  
 Epoch 182/700  
 150/150 1s 6ms/step -  
 loss: 7.0888e-05 - mae: 0.0030 - val\_loss: 6.1259e-05 - val\_mae: 0.0023  
 Epoch 183/700  
 150/150 1s 5ms/step -  
 loss: 5.9989e-05 - mae: 0.0017 - val\_loss: 5.8457e-05 - val\_mae: 0.0015  
 Epoch 184/700  
 150/150 1s 6ms/step -

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loss: 5.7955e-05 - mae: 0.0012 - val_loss: 5.7773e-05 - val_mae: 0.0011
Epoch 185/700
150/150          1s 5ms/step -
loss: 9.1844e-05 - mae: 0.0042 - val_loss: 6.0566e-05 - val_mae: 0.0018
Epoch 186/700
150/150          1s 6ms/step -
loss: 6.2248e-05 - mae: 0.0021 - val_loss: 5.7738e-05 - val_mae: 0.0011
Epoch 187/700
150/150          1s 6ms/step -
loss: 6.1483e-05 - mae: 0.0018 - val_loss: 7.4189e-05 - val_mae: 0.0043
Epoch 188/700
150/150          1s 7ms/step -
loss: 6.7990e-05 - mae: 0.0029 - val_loss: 3.8090e-04 - val_mae: 0.0178
Epoch 189/700
150/150          1s 6ms/step -
loss: 1.5997e-04 - mae: 0.0082 - val_loss: 7.7641e-05 - val_mae: 0.0043
Epoch 190/700
150/150          1s 6ms/step -
loss: 7.0850e-05 - mae: 0.0030 - val_loss: 6.2807e-05 - val_mae: 0.0026
Epoch 191/700
150/150          1s 7ms/step -
loss: 5.7809e-05 - mae: 0.0012 - val_loss: 6.4194e-05 - val_mae: 0.0027
Epoch 192/700
150/150          1s 5ms/step -
loss: 6.1740e-05 - mae: 0.0020 - val_loss: 6.4027e-05 - val_mae: 0.0027
Epoch 193/700
150/150          1s 5ms/step -
loss: 5.9726e-05 - mae: 0.0017 - val_loss: 6.9349e-05 - val_mae: 0.0031
Epoch 194/700
150/150          1s 7ms/step -
loss: 7.1760e-05 - mae: 0.0032 - val_loss: 6.0232e-05 - val_mae: 0.0018
Epoch 195/700
150/150          1s 6ms/step -
loss: 6.5420e-05 - mae: 0.0023 - val_loss: 1.8070e-04 - val_mae: 0.0099
Epoch 196/700
150/150          1s 6ms/step -
loss: 9.6114e-05 - mae: 0.0050 - val_loss: 5.8603e-05 - val_mae: 0.0014
Epoch 197/700
150/150          1s 6ms/step -
loss: 5.8702e-05 - mae: 0.0015 - val_loss: 6.1455e-05 - val_mae: 0.0023
Epoch 198/700
150/150          1s 8ms/step -
loss: 5.8648e-05 - mae: 0.0015 - val_loss: 5.8158e-05 - val_mae: 0.0014
Epoch 199/700
150/150          1s 6ms/step -
loss: 5.9514e-05 - mae: 0.0014 - val_loss: 8.0374e-05 - val_mae: 0.0040
Epoch 200/700
150/150          1s 7ms/step -

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loss: 8.4789e-05 - mae: 0.0044 - val\_loss: 9.2236e-05 - val\_mae: 0.0051  
 Epoch 201/700  
 150/150 1s 6ms/step -  
 loss: 6.8421e-05 - mae: 0.0029 - val\_loss: 6.4217e-05 - val\_mae: 0.0026  
 Epoch 202/700  
 150/150 1s 5ms/step -  
 loss: 6.2176e-05 - mae: 0.0021 - val\_loss: 5.7280e-05 - val\_mae: 0.0011  
 Epoch 203/700  
 150/150 1s 6ms/step -  
 loss: 6.8121e-05 - mae: 0.0026 - val\_loss: 6.0787e-05 - val\_mae: 0.0023  
 Epoch 204/700  
 150/150 1s 5ms/step -  
 loss: 7.9037e-05 - mae: 0.0037 - val\_loss: 6.0735e-05 - val\_mae: 0.0020  
 Epoch 205/700  
 150/150 1s 6ms/step -  
 loss: 7.5208e-05 - mae: 0.0036 - val\_loss: 5.8864e-05 - val\_mae: 0.0016  
 Epoch 206/700  
 150/150 1s 5ms/step -  
 loss: 6.7307e-05 - mae: 0.0028 - val\_loss: 5.7809e-05 - val\_mae: 0.0011  
 Epoch 207/700  
 150/150 1s 6ms/step -  
 loss: 5.9247e-05 - mae: 0.0016 - val\_loss: 1.8031e-04 - val\_mae: 0.0108  
 Epoch 208/700  
 150/150 1s 5ms/step -  
 loss: 7.9296e-05 - mae: 0.0039 - val\_loss: 6.6831e-05 - val\_mae: 0.0030  
 Epoch 209/700  
 150/150 1s 5ms/step -  
 loss: 6.1361e-05 - mae: 0.0019 - val\_loss: 7.5218e-05 - val\_mae: 0.0040  
 Epoch 210/700  
 150/150 1s 5ms/step -  
 loss: 6.8754e-05 - mae: 0.0030 - val\_loss: 2.9227e-04 - val\_mae: 0.0145  
 Epoch 211/700  
 150/150 1s 6ms/step -  
 loss: 1.3540e-04 - mae: 0.0068 - val\_loss: 6.0968e-05 - val\_mae: 0.0024  
 Epoch 212/700  
 150/150 1s 5ms/step -  
 loss: 6.0465e-05 - mae: 0.0019 - val\_loss: 6.2503e-05 - val\_mae: 0.0023  
 Epoch 213/700  
 150/150 1s 5ms/step -  
 loss: 5.9951e-05 - mae: 0.0018 - val\_loss: 5.6740e-05 - val\_mae: 8.3667e-04  
 Epoch 214/700  
 150/150 1s 7ms/step -  
 loss: 6.0145e-05 - mae: 0.0016 - val\_loss: 6.5172e-05 - val\_mae: 0.0031  
 Epoch 215/700  
 150/150 1s 6ms/step -  
 loss: 6.1315e-05 - mae: 0.0021 - val\_loss: 7.0242e-05 - val\_mae: 0.0036  
 Epoch 216/700

150/150                    1s 6ms/step -  
 loss: 7.0765e-05 - mae: 0.0030 - val\_loss: 7.3804e-04 - val\_mae: 0.0219  
 Epoch 217/700  
 150/150                    2s 10ms/step -  
 loss: 2.4787e-04 - mae: 0.0095 - val\_loss: 5.7497e-05 - val\_mae: 0.0012  
 Epoch 218/700  
 150/150                    1s 9ms/step -  
 loss: 5.8741e-05 - mae: 0.0016 - val\_loss: 6.5601e-05 - val\_mae: 0.0029  
 Epoch 219/700  
 150/150                    1s 8ms/step -  
 loss: 8.0733e-05 - mae: 0.0037 - val\_loss: 5.7443e-05 - val\_mae: 0.0014  
 Epoch 220/700  
 150/150                    1s 6ms/step -  
 loss: 5.7134e-05 - mae: 0.0011 - val\_loss: 5.7627e-05 - val\_mae: 0.0013  
 Epoch 221/700  
 150/150                    1s 5ms/step -  
 loss: 5.8002e-05 - mae: 0.0014 - val\_loss: 5.6952e-05 - val\_mae: 9.6436e-04  
 Epoch 222/700  
 150/150                    1s 6ms/step -  
 loss: 5.8690e-05 - mae: 0.0015 - val\_loss: 9.5417e-05 - val\_mae: 0.0054  
 Epoch 223/700  
 150/150                    1s 6ms/step -  
 loss: 1.1320e-04 - mae: 0.0059 - val\_loss: 5.8299e-05 - val\_mae: 0.0015  
 Epoch 224/700  
 150/150                    1s 5ms/step -  
 loss: 5.8736e-05 - mae: 0.0014 - val\_loss: 6.2138e-05 - val\_mae: 0.0026  
 Epoch 225/700  
 150/150                    1s 6ms/step -  
 loss: 5.9275e-05 - mae: 0.0017 - val\_loss: 6.2559e-05 - val\_mae: 0.0025  
 Epoch 226/700  
 150/150                    1s 5ms/step -  
 loss: 6.1696e-05 - mae: 0.0022 - val\_loss: 6.3152e-05 - val\_mae: 0.0024  
 Epoch 227/700  
 150/150                    1s 5ms/step -  
 loss: 6.8026e-05 - mae: 0.0029 - val\_loss: 5.8505e-05 - val\_mae: 0.0017  
 Epoch 228/700  
 150/150                    1s 6ms/step -  
 loss: 6.2384e-05 - mae: 0.0021 - val\_loss: 7.3590e-05 - val\_mae: 0.0037  
 Epoch 229/700  
 150/150                    1s 6ms/step -  
 loss: 6.2952e-05 - mae: 0.0022 - val\_loss: 7.2519e-05 - val\_mae: 0.0037  
 Epoch 230/700  
 150/150                    1s 7ms/step -  
 loss: 8.0716e-05 - mae: 0.0040 - val\_loss: 8.4137e-05 - val\_mae: 0.0044  
 Epoch 231/700  
 150/150                    1s 6ms/step -  
 loss: 6.3027e-05 - mae: 0.0023 - val\_loss: 5.7386e-05 - val\_mae: 0.0014  
 Epoch 232/700

150/150                    1s 6ms/step -  
 loss: 9.0020e-05 - mae: 0.0034 - val\_loss: 1.1901e-04 - val\_mae: 0.0068  
 Epoch 233/700  
 150/150                    1s 9ms/step -  
 loss: 7.6081e-05 - mae: 0.0035 - val\_loss: 5.6373e-05 - val\_mae: 8.2041e-04  
 Epoch 234/700  
 150/150                    1s 6ms/step -  
 loss: 5.7135e-05 - mae: 0.0012 - val\_loss: 6.0919e-05 - val\_mae: 0.0019  
 Epoch 235/700  
 150/150                    1s 5ms/step -  
 loss: 5.7554e-05 - mae: 0.0013 - val\_loss: 8.5858e-05 - val\_mae: 0.0054  
 Epoch 236/700  
 150/150                    1s 6ms/step -  
 loss: 6.0132e-05 - mae: 0.0019 - val\_loss: 5.7318e-05 - val\_mae: 0.0010  
 Epoch 237/700  
 150/150                    1s 5ms/step -  
 loss: 5.9886e-05 - mae: 0.0018 - val\_loss: 6.6481e-05 - val\_mae: 0.0031  
 Epoch 238/700  
 150/150                    1s 5ms/step -  
 loss: 8.0191e-05 - mae: 0.0040 - val\_loss: 6.0287e-05 - val\_mae: 0.0022  
 Epoch 239/700  
 150/150                    1s 6ms/step -  
 loss: 6.1965e-05 - mae: 0.0022 - val\_loss: 7.3001e-05 - val\_mae: 0.0041  
 Epoch 240/700  
 150/150                    1s 5ms/step -  
 loss: 8.5639e-05 - mae: 0.0042 - val\_loss: 5.7472e-05 - val\_mae: 0.0013  
 Epoch 241/700  
 150/150                    1s 6ms/step -  
 loss: 5.9327e-05 - mae: 0.0018 - val\_loss: 6.3875e-05 - val\_mae: 0.0026  
 Epoch 242/700  
 150/150                    1s 6ms/step -  
 loss: 5.8904e-05 - mae: 0.0016 - val\_loss: 5.7242e-05 - val\_mae: 0.0013  
 Epoch 243/700  
 150/150                    1s 8ms/step -  
 loss: 6.1222e-05 - mae: 0.0018 - val\_loss: 6.8656e-05 - val\_mae: 0.0032  
 Epoch 244/700  
 150/150                    1s 6ms/step -  
 loss: 6.2641e-05 - mae: 0.0023 - val\_loss: 5.6166e-05 - val\_mae: 8.2712e-04  
 Epoch 245/700  
 150/150                    1s 6ms/step -  
 loss: 6.2492e-05 - mae: 0.0022 - val\_loss: 1.6477e-04 - val\_mae: 0.0103  
 Epoch 246/700  
 150/150                    1s 6ms/step -  
 loss: 8.1025e-05 - mae: 0.0042 - val\_loss: 1.3607e-04 - val\_mae: 0.0083  
 Epoch 247/700  
 150/150                    1s 6ms/step -  
 loss: 1.4187e-04 - mae: 0.0070 - val\_loss: 6.6998e-05 - val\_mae: 0.0034  
 Epoch 248/700



150/150                    1s 6ms/step -  
 loss: 6.7340e-05 - mae: 0.0028 - val\_loss: 5.7800e-05 - val\_mae: 0.0013  
 Epoch 249/700  
 150/150                    1s 9ms/step -  
 loss: 5.7103e-05 - mae: 0.0012 - val\_loss: 9.6713e-05 - val\_mae: 0.0063  
 Epoch 250/700  
 150/150                    1s 9ms/step -  
 loss: 7.0131e-05 - mae: 0.0032 - val\_loss: 6.4537e-05 - val\_mae: 0.0030  
 Epoch 251/700  
  
 150/150                    1s 6ms/step -  
 loss: 6.1282e-05 - mae: 0.0021 - val\_loss: 5.6114e-05 - val\_mae: 6.7298e-04  
 Epoch 252/700  
 150/150                    1s 6ms/step -  
 loss: 5.7517e-05 - mae: 0.0013 - val\_loss: 1.6242e-04 - val\_mae: 0.0081  
 Epoch 253/700  
 150/150                    1s 6ms/step -  
 loss: 2.2895e-04 - mae: 0.0104 - val\_loss: 7.3125e-05 - val\_mae: 0.0038  
 Epoch 254/700  
 150/150                    1s 5ms/step -  
 loss: 6.1566e-05 - mae: 0.0021 - val\_loss: 5.6205e-05 - val\_mae: 9.4793e-04  
 Epoch 255/700  
 150/150                    1s 7ms/step -  
 loss: 5.7579e-05 - mae: 0.0014 - val\_loss: 7.1903e-05 - val\_mae: 0.0038  
 Epoch 256/700  
 150/150                    1s 5ms/step -  
 loss: 5.7582e-05 - mae: 0.0014 - val\_loss: 5.9735e-05 - val\_mae: 0.0021  
 Epoch 257/700  
 150/150                    1s 5ms/step -  
 loss: 6.0385e-05 - mae: 0.0020 - val\_loss: 6.5346e-05 - val\_mae: 0.0026  
 Epoch 258/700  
 150/150                    1s 6ms/step -  
 loss: 6.1084e-05 - mae: 0.0021 - val\_loss: 5.6038e-05 - val\_mae: 8.3017e-04  
 Epoch 259/700  
 150/150                    1s 6ms/step -  
 loss: 5.9939e-05 - mae: 0.0016 - val\_loss: 1.2694e-04 - val\_mae: 0.0076  
 Epoch 260/700  
 150/150                    1s 6ms/step -  
 loss: 1.2869e-04 - mae: 0.0068 - val\_loss: 5.7887e-05 - val\_mae: 0.0016  
 Epoch 261/700  
 150/150                    1s 5ms/step -  
 loss: 5.7738e-05 - mae: 0.0014 - val\_loss: 8.4206e-05 - val\_mae: 0.0053  
 Epoch 262/700  
 150/150                    1s 5ms/step -  
 loss: 5.8869e-05 - mae: 0.0018 - val\_loss: 6.5289e-05 - val\_mae: 0.0029  
 Epoch 263/700  
 150/150                    1s 5ms/step -  
 loss: 5.8157e-05 - mae: 0.0015 - val\_loss: 7.0034e-05 - val\_mae: 0.0031

Epoch 264/700  
150/150 1s 6ms/step -  
loss: 6.1585e-05 - mae: 0.0022 - val\_loss: 6.6878e-05 - val\_mae: 0.0033  
Epoch 265/700  
150/150 1s 6ms/step -  
loss: 6.6289e-05 - mae: 0.0028 - val\_loss: 6.7824e-05 - val\_mae: 0.0032  
Epoch 266/700  
150/150 1s 5ms/step -  
loss: 8.7267e-05 - mae: 0.0048 - val\_loss: 9.9569e-05 - val\_mae: 0.0056  
Epoch 267/700  
150/150 1s 5ms/step -  
loss: 6.7741e-05 - mae: 0.0029 - val\_loss: 6.7956e-05 - val\_mae: 0.0033  
Epoch 268/700  
150/150 1s 5ms/step -  
loss: 6.0777e-05 - mae: 0.0021 - val\_loss: 5.7897e-05 - val\_mae: 0.0016  
Epoch 269/700  
150/150 1s 5ms/step -  
loss: 6.4941e-05 - mae: 0.0025 - val\_loss: 8.7227e-05 - val\_mae: 0.0050  
Epoch 270/700  
150/150 1s 5ms/step -  
loss: 1.6318e-04 - mae: 0.0075 - val\_loss: 7.8126e-05 - val\_mae: 0.0039  
Epoch 271/700  
150/150 1s 5ms/step -  
loss: 7.0541e-05 - mae: 0.0032 - val\_loss: 5.6474e-05 - val\_mae: 0.0011  
Epoch 272/700  
150/150 1s 6ms/step -  
loss: 5.6235e-05 - mae: 0.0010 - val\_loss: 6.4327e-05 - val\_mae: 0.0028  
Epoch 273/700  
150/150 1s 6ms/step -  
loss: 5.8564e-05 - mae: 0.0016 - val\_loss: 1.1570e-04 - val\_mae: 0.0072  
Epoch 274/700  
150/150 1s 6ms/step -  
loss: 9.9044e-05 - mae: 0.0054 - val\_loss: 5.7767e-05 - val\_mae: 0.0017  
Epoch 275/700  
150/150 1s 6ms/step -  
loss: 5.7223e-05 - mae: 0.0013 - val\_loss: 5.8855e-05 - val\_mae: 0.0017  
Epoch 276/700  
150/150 1s 5ms/step -  
loss: 6.7230e-05 - mae: 0.0025 - val\_loss: 5.1179e-04 - val\_mae: 0.0168  
Epoch 277/700  
150/150 1s 6ms/step -  
loss: 1.1595e-04 - mae: 0.0058 - val\_loss: 5.5871e-05 - val\_mae: 9.8396e-04  
Epoch 278/700  
150/150 1s 6ms/step -  
loss: 5.6157e-05 - mae: 0.0010 - val\_loss: 5.8635e-05 - val\_mae: 0.0017  
Epoch 279/700  
150/150 1s 6ms/step -  
loss: 5.6713e-05 - mae: 0.0012 - val\_loss: 5.5569e-05 - val\_mae: 7.9118e-04

Epoch 280/700  
150/150 1s 5ms/step -  
loss: 5.9417e-05 - mae: 0.0017 - val\_loss: 7.0600e-05 - val\_mae: 0.0037

Epoch 281/700  
150/150 1s 6ms/step -  
loss: 8.5248e-05 - mae: 0.0044 - val\_loss: 6.9955e-05 - val\_mae: 0.0036

Epoch 282/700  
150/150 1s 6ms/step -  
loss: 7.5890e-05 - mae: 0.0037 - val\_loss: 6.6347e-05 - val\_mae: 0.0034

Epoch 283/700  
150/150 1s 5ms/step -  
loss: 5.9264e-05 - mae: 0.0018 - val\_loss: 9.0852e-05 - val\_mae: 0.0060

Epoch 284/700  
150/150 1s 6ms/step -  
loss: 6.4769e-05 - mae: 0.0027 - val\_loss: 5.9152e-05 - val\_mae: 0.0020

Epoch 285/700  
150/150 1s 6ms/step -  
loss: 6.2612e-05 - mae: 0.0023 - val\_loss: 6.0095e-05 - val\_mae: 0.0022

Epoch 286/700  
150/150 1s 6ms/step -  
loss: 6.0333e-05 - mae: 0.0020 - val\_loss: 7.2553e-05 - val\_mae: 0.0041

Epoch 287/700  
150/150 1s 6ms/step -  
loss: 6.3156e-05 - mae: 0.0024 - val\_loss: 5.5955e-05 - val\_mae: 9.4896e-04

Epoch 288/700  
150/150 1s 6ms/step -  
loss: 6.2199e-05 - mae: 0.0021 - val\_loss: 5.8139e-05 - val\_mae: 0.0014

Epoch 289/700  
150/150 1s 6ms/step -  
loss: 1.0359e-04 - mae: 0.0053 - val\_loss: 5.6181e-05 - val\_mae: 0.0010

Epoch 290/700  
150/150 1s 6ms/step -  
loss: 5.9636e-05 - mae: 0.0019 - val\_loss: 5.6986e-05 - val\_mae: 0.0013

Epoch 291/700  
150/150 1s 5ms/step -  
loss: 5.7043e-05 - mae: 0.0014 - val\_loss: 7.8549e-05 - val\_mae: 0.0047

Epoch 292/700  
150/150 1s 6ms/step -  
loss: 5.9041e-05 - mae: 0.0018 - val\_loss: 5.7255e-05 - val\_mae: 0.0015

Epoch 293/700  
150/150 1s 6ms/step -  
loss: 7.5627e-05 - mae: 0.0037 - val\_loss: 5.7972e-05 - val\_mae: 0.0017

Epoch 294/700  
150/150 1s 6ms/step -  
loss: 5.7530e-05 - mae: 0.0015 - val\_loss: 7.8303e-05 - val\_mae: 0.0040

Epoch 295/700  
150/150 1s 6ms/step -  
loss: 9.9489e-05 - mae: 0.0051 - val\_loss: 6.1889e-05 - val\_mae: 0.0026

Epoch 296/700  
150/150 1s 6ms/step -  
loss: 8.1070e-05 - mae: 0.0041 - val\_loss: 5.9651e-05 - val\_mae: 0.0015  
Epoch 297/700  
150/150 1s 6ms/step -  
loss: 5.9725e-05 - mae: 0.0020 - val\_loss: 8.3525e-05 - val\_mae: 0.0053  
Epoch 298/700  
150/150 1s 6ms/step -  
loss: 5.9602e-05 - mae: 0.0020 - val\_loss: 6.1913e-05 - val\_mae: 0.0020  
Epoch 299/700  
150/150 1s 5ms/step -  
loss: 6.1416e-05 - mae: 0.0022 - val\_loss: 7.2063e-05 - val\_mae: 0.0039  
Epoch 300/700  
150/150 1s 6ms/step -  
loss: 7.3589e-05 - mae: 0.0035 - val\_loss: 6.1169e-05 - val\_mae: 0.0023  
Epoch 301/700  
150/150 1s 5ms/step -  
loss: 5.7200e-05 - mae: 0.0015 - val\_loss: 6.0800e-05 - val\_mae: 0.0026  
Epoch 302/700  
150/150 1s 5ms/step -  
loss: 8.0386e-05 - mae: 0.0039 - val\_loss: 5.5745e-05 - val\_mae: 0.0010  
Epoch 303/700  
150/150 1s 6ms/step -  
loss: 6.1907e-05 - mae: 0.0023 - val\_loss: 5.5742e-05 - val\_mae: 0.0010  
Epoch 304/700  
150/150 1s 6ms/step -  
loss: 5.7761e-05 - mae: 0.0016 - val\_loss: 1.5563e-04 - val\_mae: 0.0098  
Epoch 305/700  
150/150 1s 6ms/step -  
loss: 7.3819e-05 - mae: 0.0036 - val\_loss: 5.6783e-05 - val\_mae: 0.0015  
Epoch 306/700  
150/150 1s 7ms/step -  
loss: 7.1836e-05 - mae: 0.0033 - val\_loss: 4.9003e-04 - val\_mae: 0.0202  
Epoch 307/700  
150/150 1s 6ms/step -  
loss: 1.8808e-04 - mae: 0.0089 - val\_loss: 5.6369e-05 - val\_mae: 0.0013  
Epoch 308/700  
150/150 1s 6ms/step -  
loss: 5.6452e-05 - mae: 0.0013 - val\_loss: 6.0378e-05 - val\_mae: 0.0021  
Epoch 309/700  
150/150 1s 6ms/step -  
loss: 5.8324e-05 - mae: 0.0017 - val\_loss: 5.5846e-05 - val\_mae: 0.0010  
Epoch 310/700  
150/150 1s 6ms/step -  
loss: 6.7774e-05 - mae: 0.0026 - val\_loss: 6.1792e-05 - val\_mae: 0.0024  
Epoch 311/700  
150/150 1s 6ms/step -

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loss: 5.7723e-05 - mae: 0.0015 - val_loss: 1.5894e-04 - val_mae: 0.0094
Epoch 312/700
150/150          1s 6ms/step -
loss: 9.8473e-05 - mae: 0.0054 - val_loss: 5.8503e-05 - val_mae: 0.0020
Epoch 313/700
150/150          1s 6ms/step -
loss: 5.7127e-05 - mae: 0.0015 - val_loss: 5.6828e-05 - val_mae: 0.0016
Epoch 314/700
150/150          1s 7ms/step -
loss: 5.6423e-05 - mae: 0.0013 - val_loss: 5.5643e-05 - val_mae: 9.8274e-04
Epoch 315/700
150/150          2s 13ms/step -
loss: 6.2213e-05 - mae: 0.0023 - val_loss: 7.2028e-05 - val_mae: 0.0037
Epoch 316/700
150/150          1s 6ms/step -
loss: 1.1803e-04 - mae: 0.0066 - val_loss: 6.8566e-05 - val_mae: 0.0031
Epoch 317/700
150/150          1s 6ms/step -
loss: 5.7267e-05 - mae: 0.0014 - val_loss: 5.7604e-05 - val_mae: 0.0017
Epoch 318/700
150/150          1s 6ms/step -
loss: 5.7751e-05 - mae: 0.0016 - val_loss: 5.8322e-05 - val_mae: 0.0016
Epoch 319/700
150/150          1s 6ms/step -
loss: 6.1977e-05 - mae: 0.0022 - val_loss: 5.8553e-05 - val_mae: 0.0020
Epoch 320/700
150/150          1s 6ms/step -
loss: 5.6078e-05 - mae: 0.0012 - val_loss: 6.1059e-05 - val_mae: 0.0023
Epoch 321/700
150/150          1s 8ms/step -
loss: 6.5976e-05 - mae: 0.0029 - val_loss: 5.9820e-05 - val_mae: 0.0022
Epoch 322/700
150/150          1s 7ms/step -
loss: 5.8073e-05 - mae: 0.0017 - val_loss: 5.6932e-05 - val_mae: 0.0016
Epoch 323/700
150/150          1s 5ms/step -
loss: 5.9280e-05 - mae: 0.0019 - val_loss: 6.6769e-05 - val_mae: 0.0028
Epoch 324/700
150/150          1s 6ms/step -
loss: 2.4671e-04 - mae: 0.0092 - val_loss: 5.6101e-05 - val_mae: 0.0012
Epoch 325/700
150/150          1s 7ms/step -
loss: 5.5990e-05 - mae: 0.0012 - val_loss: 5.6095e-05 - val_mae: 0.0012
Epoch 326/700
150/150          1s 6ms/step -
loss: 5.5674e-05 - mae: 0.0011 - val_loss: 5.5417e-05 - val_mae: 0.0010
Epoch 327/700
150/150          1s 6ms/step -

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loss: 5.5878e-05 - mae: 0.0012 - val\_loss: 5.5803e-05 - val\_mae: 9.0387e-04  
 Epoch 328/700  
 150/150 1s 6ms/step -  
 loss: 5.5604e-05 - mae: 0.0010 - val\_loss: 5.5942e-05 - val\_mae: 0.0012  
 Epoch 329/700  
 150/150 1s 6ms/step -  
 loss: 5.5929e-05 - mae: 0.0012 - val\_loss: 5.4967e-05 - val\_mae: 7.1951e-04  
 Epoch 330/700  
 150/150 1s 5ms/step -  
 loss: 5.6154e-05 - mae: 0.0013 - val\_loss: 5.5393e-05 - val\_mae: 0.0010  
 Epoch 331/700  
 150/150 1s 6ms/step -  
 loss: 5.6002e-05 - mae: 0.0012 - val\_loss: 5.5310e-05 - val\_mae: 0.0011  
 Epoch 332/700  
 150/150 1s 6ms/step -  
 loss: 5.8056e-05 - mae: 0.0017 - val\_loss: 1.6816e-04 - val\_mae: 0.0086  
 Epoch 333/700  
 150/150 1s 5ms/step -  
 loss: 2.5401e-04 - mae: 0.0112 - val\_loss: 5.4971e-05 - val\_mae: 7.3572e-04  
 Epoch 334/700  
 150/150 1s 6ms/step -  
 loss: 5.5688e-05 - mae: 0.0011 - val\_loss: 5.6344e-05 - val\_mae: 9.3346e-04  
 Epoch 335/700  
 150/150 1s 7ms/step -  
 loss: 5.5318e-05 - mae: 9.4291e-04 - val\_loss: 5.6687e-05 - val\_mae: 0.0012  
 Epoch 336/700  
 150/150 1s 6ms/step -  
 loss: 5.7519e-05 - mae: 0.0016 - val\_loss: 5.8810e-05 - val\_mae: 0.0017  
 Epoch 337/700  
 150/150 1s 6ms/step -  
 loss: 5.9176e-05 - mae: 0.0020 - val\_loss: 5.8182e-05 - val\_mae: 0.0018  
 Epoch 338/700  
 150/150 1s 6ms/step -  
 loss: 6.2867e-05 - mae: 0.0025 - val\_loss: 1.1748e-04 - val\_mae: 0.0061  
 Epoch 339/700  
 150/150 1s 6ms/step -  
 loss: 1.8651e-04 - mae: 0.0087 - val\_loss: 5.6228e-05 - val\_mae: 0.0014  
 Epoch 340/700  
 150/150 1s 6ms/step -  
 loss: 5.5429e-05 - mae: 0.0010 - val\_loss: 5.5835e-05 - val\_mae: 0.0012  
 Epoch 341/700  
 150/150 1s 6ms/step -  
 loss: 5.6268e-05 - mae: 0.0013 - val\_loss: 6.0395e-05 - val\_mae: 0.0022  
 Epoch 342/700  
 150/150 2s 11ms/step -  
 loss: 5.6049e-05 - mae: 0.0012 - val\_loss: 5.6136e-05 - val\_mae: 0.0013  
 Epoch 343/700  
 150/150 1s 6ms/step -

loss: 5.7920e-05 - mae: 0.0017 - val\_loss: 6.1023e-05 - val\_mae: 0.0024  
 Epoch 344/700  
 150/150 1s 6ms/step -  
 loss: 6.0383e-05 - mae: 0.0021 - val\_loss: 7.0199e-05 - val\_mae: 0.0036  
 Epoch 345/700  
 150/150 1s 6ms/step -  
 loss: 6.6431e-05 - mae: 0.0030 - val\_loss: 1.0414e-04 - val\_mae: 0.0062  
 Epoch 346/700  
 150/150 1s 6ms/step -  
 loss: 9.7291e-05 - mae: 0.0056 - val\_loss: 6.3564e-05 - val\_mae: 0.0029  
 Epoch 347/700  
 150/150 1s 6ms/step -  
 loss: 5.6357e-05 - mae: 0.0014 - val\_loss: 5.6830e-05 - val\_mae: 0.0015  
 Epoch 348/700  
 150/150 1s 7ms/step -  
 loss: 6.8759e-05 - mae: 0.0025 - val\_loss: 5.1274e-04 - val\_mae: 0.0199  
 Epoch 349/700  
 150/150 1s 6ms/step -  
 loss: 1.0603e-04 - mae: 0.0055 - val\_loss: 1.1704e-04 - val\_mae: 0.0067  
 Epoch 350/700  
 150/150 1s 6ms/step -  
 loss: 6.8432e-05 - mae: 0.0028 - val\_loss: 5.5020e-05 - val\_mae: 8.3799e-04  
 Epoch 351/700  
 150/150 1s 6ms/step -  
 loss: 5.5980e-05 - mae: 0.0013 - val\_loss: 5.5044e-05 - val\_mae: 8.7480e-04  
 Epoch 352/700  
 150/150 1s 6ms/step -  
 loss: 6.3310e-05 - mae: 0.0022 - val\_loss: 1.8527e-04 - val\_mae: 0.0091  
 Epoch 353/700  
 150/150 1s 5ms/step -  
 loss: 9.3120e-05 - mae: 0.0045 - val\_loss: 5.7361e-05 - val\_mae: 0.0016  
 Epoch 354/700  
 150/150 1s 6ms/step -  
 loss: 5.6972e-05 - mae: 0.0015 - val\_loss: 5.4810e-05 - val\_mae: 8.6275e-04  
 Epoch 355/700  
 150/150 1s 7ms/step -  
 loss: 5.5134e-05 - mae: 9.6398e-04 - val\_loss: 5.6106e-05 - val\_mae: 0.0013  
 Epoch 356/700  
 150/150 1s 5ms/step -  
 loss: 5.6285e-05 - mae: 0.0014 - val\_loss: 7.1473e-05 - val\_mae: 0.0041  
 Epoch 357/700  
 150/150 1s 5ms/step -  
 loss: 6.4438e-05 - mae: 0.0026 - val\_loss: 5.5050e-05 - val\_mae: 0.0010  
 Epoch 358/700  
 150/150 1s 6ms/step -  
 loss: 6.8734e-05 - mae: 0.0025 - val\_loss: 3.7157e-04 - val\_mae: 0.0170  
 Epoch 359/700

150/150                    1s 6ms/step -  
 loss: 1.0791e-04 - mae: 0.0058 - val\_loss: 5.5125e-05 - val\_mae: 8.4380e-04  
 Epoch 360/700  
 150/150                    1s 6ms/step -  
 loss: 5.5654e-05 - mae: 0.0012 - val\_loss: 5.9039e-05 - val\_mae: 0.0020  
 Epoch 361/700  
 150/150                    1s 5ms/step -  
 loss: 5.9800e-05 - mae: 0.0021 - val\_loss: 6.2848e-05 - val\_mae: 0.0029  
 Epoch 362/700  
 150/150                    1s 5ms/step -  
 loss: 8.1223e-05 - mae: 0.0041 - val\_loss: 5.7090e-05 - val\_mae: 0.0017  
 Epoch 363/700  
 150/150                    1s 5ms/step -  
 loss: 5.6211e-05 - mae: 0.0014 - val\_loss: 5.9717e-05 - val\_mae: 0.0022  
 Epoch 364/700  
 150/150                    1s 6ms/step -  
 loss: 6.4436e-05 - mae: 0.0026 - val\_loss: 8.6642e-05 - val\_mae: 0.0055  
 Epoch 365/700  
 150/150                    1s 6ms/step -  
 loss: 7.3385e-05 - mae: 0.0037 - val\_loss: 2.0818e-04 - val\_mae: 0.0110  
 Epoch 366/700  
 150/150                    1s 7ms/step -  
 loss: 7.5859e-05 - mae: 0.0038 - val\_loss: 7.5179e-05 - val\_mae: 0.0040  
 Epoch 367/700  
 150/150                    1s 5ms/step -  
 loss: 1.2214e-04 - mae: 0.0062 - val\_loss: 6.0793e-05 - val\_mae: 0.0027  
 Epoch 368/700  
 150/150                    1s 5ms/step -  
 loss: 5.9052e-05 - mae: 0.0020 - val\_loss: 5.5193e-05 - val\_mae: 8.5659e-04  
 Epoch 369/700  
 150/150                    1s 5ms/step -  
 loss: 6.0910e-05 - mae: 0.0021 - val\_loss: 5.9404e-05 - val\_mae: 0.0023  
 Epoch 370/700  
 150/150                    1s 5ms/step -  
 loss: 5.8049e-05 - mae: 0.0018 - val\_loss: 6.9938e-05 - val\_mae: 0.0035  
 Epoch 371/700  
 150/150                    1s 5ms/step -  
 loss: 5.9393e-05 - mae: 0.0020 - val\_loss: 9.0485e-05 - val\_mae: 0.0060  
 Epoch 372/700  
 150/150                    1s 5ms/step -  
 loss: 7.7336e-05 - mae: 0.0040 - val\_loss: 7.8018e-05 - val\_mae: 0.0047  
 Epoch 373/700  
 150/150                    1s 5ms/step -  
 loss: 6.0215e-05 - mae: 0.0021 - val\_loss: 5.5855e-05 - val\_mae: 0.0014  
 Epoch 374/700  
 150/150                    1s 5ms/step -  
 loss: 5.9321e-05 - mae: 0.0020 - val\_loss: 9.8371e-05 - val\_mae: 0.0066  
 Epoch 375/700



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150/150          1s 5ms/step -
loss: 1.6128e-04 - mae: 0.0075 - val_loss: 6.8864e-05 - val_mae: 0.0031
Epoch 376/700
150/150          1s 6ms/step -
loss: 6.2236e-05 - mae: 0.0023 - val_loss: 5.5695e-05 - val_mae: 0.0014
Epoch 377/700
150/150          1s 5ms/step -
loss: 5.4851e-05 - mae: 8.7647e-04 - val_loss: 5.5012e-05 - val_mae: 9.7616e-04
Epoch 378/700
150/150          1s 5ms/step -
loss: 5.4975e-05 - mae: 9.7051e-04 - val_loss: 5.7468e-05 - val_mae: 0.0018
Epoch 379/700
150/150          1s 5ms/step -
loss: 5.5399e-05 - mae: 0.0011 - val_loss: 6.0123e-05 - val_mae: 0.0026
Epoch 380/700
150/150          1s 6ms/step -
loss: 5.6823e-05 - mae: 0.0016 - val_loss: 5.5171e-05 - val_mae: 9.6613e-04
Epoch 381/700
150/150          1s 5ms/step -
loss: 5.5245e-05 - mae: 0.0011 - val_loss: 5.4560e-05 - val_mae: 7.6728e-04
Epoch 382/700
150/150          1s 5ms/step -
loss: 6.0394e-05 - mae: 0.0022 - val_loss: 5.6794e-05 - val_mae: 0.0016
Epoch 383/700
150/150          1s 5ms/step -
loss: 6.5382e-05 - mae: 0.0025 - val_loss: 5.6766e-05 - val_mae: 0.0014
Epoch 384/700
150/150          1s 6ms/step -
loss: 5.5712e-05 - mae: 0.0013 - val_loss: 5.9859e-05 - val_mae: 0.0025
Epoch 385/700
150/150          1s 6ms/step -
loss: 5.7006e-05 - mae: 0.0015 - val_loss: 5.6756e-05 - val_mae: 0.0015
Epoch 386/700
150/150          1s 8ms/step -
loss: 6.0766e-05 - mae: 0.0022 - val_loss: 7.4246e-05 - val_mae: 0.0044
Epoch 387/700
150/150          1s 5ms/step -
loss: 6.2172e-05 - mae: 0.0026 - val_loss: 5.4728e-05 - val_mae: 9.7409e-04
Epoch 388/700
150/150          1s 5ms/step -
loss: 7.0826e-05 - mae: 0.0028 - val_loss: 1.9120e-04 - val_mae: 0.0104
Epoch 389/700
150/150          1s 5ms/step -
loss: 1.1212e-04 - mae: 0.0057 - val_loss: 5.4908e-05 - val_mae: 9.7431e-04
Epoch 390/700
150/150          1s 5ms/step -
loss: 5.5559e-05 - mae: 0.0012 - val_loss: 5.6788e-05 - val_mae: 0.0015
Epoch 391/700

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150/150                    2s 12ms/step -  
 loss: 5.8373e-05 - mae: 0.0018 - val\_loss: 5.5857e-05 - val\_mae: 0.0015  
 Epoch 392/700  
 150/150                    1s 6ms/step -  
 loss: 6.1395e-05 - mae: 0.0023 - val\_loss: 5.6105e-05 - val\_mae: 0.0016  
 Epoch 393/700  
 150/150                    1s 6ms/step -  
 loss: 1.0221e-04 - mae: 0.0055 - val\_loss: 7.1916e-05 - val\_mae: 0.0036  
 Epoch 394/700  
 150/150                    1s 5ms/step -  
 loss: 7.4333e-05 - mae: 0.0036 - val\_loss: 5.4497e-05 - val\_mae: 7.6632e-04  
 Epoch 395/700  
 150/150                    1s 6ms/step -  
 loss: 5.4900e-05 - mae: 0.0010 - val\_loss: 5.8129e-05 - val\_mae: 0.0021  
 Epoch 396/700  
 150/150                    1s 7ms/step -  
 loss: 5.8627e-05 - mae: 0.0017 - val\_loss: 5.7461e-05 - val\_mae: 0.0020  
 Epoch 397/700  
 150/150                    1s 5ms/step -  
 loss: 5.4948e-05 - mae: 0.0011 - val\_loss: 5.6048e-05 - val\_mae: 0.0013  
 Epoch 398/700  
 150/150                    1s 5ms/step -  
 loss: 5.7279e-05 - mae: 0.0016 - val\_loss: 1.0028e-04 - val\_mae: 0.0063  
 Epoch 399/700  
 150/150                    1s 6ms/step -  
 loss: 5.8832e-05 - mae: 0.0019 - val\_loss: 9.8384e-05 - val\_mae: 0.0064  
 Epoch 400/700  
 150/150                    1s 6ms/step -  
 loss: 7.0417e-05 - mae: 0.0033 - val\_loss: 5.6526e-05 - val\_mae: 0.0016  
 Epoch 401/700  
 150/150                    1s 5ms/step -  
 loss: 5.8259e-05 - mae: 0.0020 - val\_loss: 5.5605e-05 - val\_mae: 0.0013  
 Epoch 402/700  
 150/150                    1s 5ms/step -  
 loss: 8.7679e-05 - mae: 0.0044 - val\_loss: 1.5179e-04 - val\_mae: 0.0097  
 Epoch 403/700  
 150/150                    1s 5ms/step -  
 loss: 1.0761e-04 - mae: 0.0057 - val\_loss: 5.8788e-05 - val\_mae: 0.0022  
 Epoch 404/700  
 150/150                    1s 5ms/step -  
 loss: 5.8983e-05 - mae: 0.0020 - val\_loss: 5.5842e-05 - val\_mae: 0.0015  
 Epoch 405/700  
 150/150                    1s 5ms/step -  
 loss: 5.5321e-05 - mae: 0.0012 - val\_loss: 7.4648e-05 - val\_mae: 0.0045  
 Epoch 406/700  
 150/150                    1s 5ms/step -  
 loss: 6.2636e-05 - mae: 0.0025 - val\_loss: 6.5954e-05 - val\_mae: 0.0034

Epoch 407/700  
150/150 1s 6ms/step -  
loss: 1.0006e-04 - mae: 0.0054 - val\_loss: 5.8422e-05 - val\_mae: 0.0019

Epoch 408/700  
150/150 1s 5ms/step -  
loss: 6.6218e-05 - mae: 0.0028 - val\_loss: 6.0334e-05 - val\_mae: 0.0023

Epoch 409/700  
150/150 1s 6ms/step -  
loss: 5.6588e-05 - mae: 0.0015 - val\_loss: 6.2512e-05 - val\_mae: 0.0027

Epoch 410/700  
150/150 1s 6ms/step -  
loss: 6.0878e-05 - mae: 0.0023 - val\_loss: 5.5572e-05 - val\_mae: 9.0929e-04

Epoch 411/700  
150/150 1s 6ms/step -  
loss: 5.8323e-05 - mae: 0.0019 - val\_loss: 5.4423e-05 - val\_mae: 8.9854e-04

Epoch 412/700  
150/150 1s 6ms/step -  
loss: 8.5473e-05 - mae: 0.0043 - val\_loss: 1.0077e-04 - val\_mae: 0.0064

Epoch 413/700  
150/150 1s 6ms/step -  
loss: 5.9100e-05 - mae: 0.0019 - val\_loss: 5.6099e-05 - val\_mae: 0.0017

Epoch 414/700  
150/150 1s 8ms/step -  
loss: 6.0513e-05 - mae: 0.0021 - val\_loss: 7.8587e-05 - val\_mae: 0.0041

Epoch 415/700  
150/150 1s 6ms/step -  
loss: 9.2494e-05 - mae: 0.0048 - val\_loss: 6.8923e-05 - val\_mae: 0.0036

Epoch 416/700  
150/150 1s 8ms/step -  
loss: 6.9838e-05 - mae: 0.0032 - val\_loss: 5.4352e-05 - val\_mae: 9.3980e-04

Epoch 417/700  
150/150 2s 10ms/step -  
loss: 5.6133e-05 - mae: 0.0015 - val\_loss: 5.8639e-05 - val\_mae: 0.0024

Epoch 418/700  
150/150 1s 7ms/step -  
loss: 5.7025e-05 - mae: 0.0015 - val\_loss: 5.4285e-05 - val\_mae: 9.0437e-04

Epoch 419/700  
150/150 1s 6ms/step -  
loss: 5.5518e-05 - mae: 0.0013 - val\_loss: 5.6366e-05 - val\_mae: 0.0014

Epoch 420/700  
150/150 1s 6ms/step -  
loss: 8.8454e-05 - mae: 0.0045 - val\_loss: 7.4081e-05 - val\_mae: 0.0043

Epoch 421/700  
150/150 1s 6ms/step -  
loss: 6.0448e-05 - mae: 0.0023 - val\_loss: 6.6037e-05 - val\_mae: 0.0033

Epoch 422/700  
150/150 1s 6ms/step -  
loss: 5.8704e-05 - mae: 0.0020 - val\_loss: 5.5665e-05 - val\_mae: 0.0014

Epoch 423/700  
150/150 1s 7ms/step -  
loss: 6.0396e-05 - mae: 0.0020 - val\_loss: 7.7774e-05 - val\_mae: 0.0049

Epoch 424/700  
150/150 1s 5ms/step -  
loss: 5.8255e-05 - mae: 0.0020 - val\_loss: 6.3369e-05 - val\_mae: 0.0030

Epoch 425/700  
150/150 1s 6ms/step -  
loss: 8.0376e-05 - mae: 0.0035 - val\_loss: 6.2416e-05 - val\_mae: 0.0029

Epoch 426/700  
150/150 1s 5ms/step -  
loss: 6.7408e-05 - mae: 0.0028 - val\_loss: 6.2939e-05 - val\_mae: 0.0030

Epoch 427/700  
150/150 1s 6ms/step -  
loss: 6.0385e-05 - mae: 0.0022 - val\_loss: 5.4765e-05 - val\_mae: 0.0013

Epoch 428/700  
150/150 1s 6ms/step -  
loss: 5.6417e-05 - mae: 0.0015 - val\_loss: 5.7368e-05 - val\_mae: 0.0020

Epoch 429/700  
150/150 1s 6ms/step -  
loss: 7.3491e-05 - mae: 0.0036 - val\_loss: 5.8096e-05 - val\_mae: 0.0020

Epoch 430/700  
150/150 1s 5ms/step -  
loss: 5.6070e-05 - mae: 0.0016 - val\_loss: 5.4256e-05 - val\_mae: 9.6399e-04

Epoch 431/700  
150/150 1s 5ms/step -  
loss: 6.4477e-05 - mae: 0.0023 - val\_loss: 5.8400e-05 - val\_mae: 0.0022

Epoch 432/700  
150/150 1s 6ms/step -  
loss: 5.7173e-05 - mae: 0.0018 - val\_loss: 5.4536e-05 - val\_mae: 0.0011

Epoch 433/700  
150/150 1s 5ms/step -  
loss: 6.3148e-05 - mae: 0.0027 - val\_loss: 1.1511e-04 - val\_mae: 0.0072

Epoch 434/700  
150/150 1s 5ms/step -  
loss: 8.2649e-05 - mae: 0.0043 - val\_loss: 6.6167e-05 - val\_mae: 0.0033

Epoch 435/700  
150/150 1s 5ms/step -  
loss: 6.0624e-05 - mae: 0.0022 - val\_loss: 6.4701e-05 - val\_mae: 0.0031

Epoch 436/700  
150/150 1s 5ms/step -  
loss: 8.9913e-05 - mae: 0.0047 - val\_loss: 5.6455e-05 - val\_mae: 0.0017

Epoch 437/700  
150/150 1s 5ms/step -  
loss: 5.6661e-05 - mae: 0.0017 - val\_loss: 6.3404e-05 - val\_mae: 0.0030

Epoch 438/700  
150/150 1s 5ms/step -  
loss: 6.0208e-05 - mae: 0.0022 - val\_loss: 6.3681e-05 - val\_mae: 0.0029

Epoch 439/700  
150/150 1s 6ms/step -  
loss: 6.3205e-05 - mae: 0.0027 - val\_loss: 6.8016e-05 - val\_mae: 0.0035  
Epoch 440/700  
150/150 1s 6ms/step -  
loss: 1.0023e-04 - mae: 0.0045 - val\_loss: 1.5010e-04 - val\_mae: 0.0096  
Epoch 441/700  
150/150 1s 5ms/step -  
loss: 6.4298e-05 - mae: 0.0026 - val\_loss: 5.6395e-05 - val\_mae: 0.0019  
Epoch 442/700  
150/150 1s 6ms/step -  
loss: 5.4631e-05 - mae: 0.0012 - val\_loss: 5.8999e-05 - val\_mae: 0.0023  
Epoch 443/700  
150/150 1s 7ms/step -  
loss: 5.9294e-05 - mae: 0.0022 - val\_loss: 5.8008e-05 - val\_mae: 0.0019  
Epoch 444/700  
150/150 1s 7ms/step -  
loss: 6.3364e-05 - mae: 0.0025 - val\_loss: 6.2326e-05 - val\_mae: 0.0026  
Epoch 445/700  
150/150 1s 6ms/step -  
loss: 6.8539e-05 - mae: 0.0030 - val\_loss: 5.6982e-05 - val\_mae: 0.0018  
Epoch 446/700  
150/150 1s 5ms/step -  
loss: 6.4160e-05 - mae: 0.0028 - val\_loss: 9.8388e-05 - val\_mae: 0.0066  
Epoch 447/700  
150/150 1s 6ms/step -  
loss: 6.1870e-05 - mae: 0.0024 - val\_loss: 6.2370e-05 - val\_mae: 0.0032  
Epoch 448/700  
150/150 1s 6ms/step -  
loss: 5.5625e-05 - mae: 0.0015 - val\_loss: 5.6720e-05 - val\_mae: 0.0018  
Epoch 449/700  
150/150 1s 6ms/step -  
loss: 9.8109e-05 - mae: 0.0049 - val\_loss: 5.8314e-05 - val\_mae: 0.0020  
Epoch 450/700  
150/150 1s 6ms/step -  
loss: 5.9169e-05 - mae: 0.0021 - val\_loss: 5.5006e-05 - val\_mae: 0.0014  
Epoch 451/700  
150/150 1s 6ms/step -  
loss: 5.6097e-05 - mae: 0.0015 - val\_loss: 5.4629e-05 - val\_mae: 0.0013  
Epoch 452/700  
150/150 1s 6ms/step -  
loss: 5.7287e-05 - mae: 0.0018 - val\_loss: 6.2988e-05 - val\_mae: 0.0032  
Epoch 453/700  
150/150 1s 5ms/step -  
loss: 6.7526e-05 - mae: 0.0032 - val\_loss: 7.5155e-05 - val\_mae: 0.0044  
Epoch 454/700  
150/150 1s 6ms/step -

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loss: 6.4127e-05 - mae: 0.0027 - val_loss: 6.1947e-05 - val_mae: 0.0026
Epoch 455/700
150/150          1s 5ms/step -
loss: 7.1899e-05 - mae: 0.0036 - val_loss: 8.7246e-05 - val_mae: 0.0049
Epoch 456/700
150/150          1s 5ms/step -
loss: 8.0120e-05 - mae: 0.0037 - val_loss: 5.6034e-05 - val_mae: 0.0016
Epoch 457/700
150/150          1s 6ms/step -
loss: 5.6941e-05 - mae: 0.0016 - val_loss: 8.8672e-05 - val_mae: 0.0055
Epoch 458/700
150/150          1s 6ms/step -
loss: 6.3171e-05 - mae: 0.0026 - val_loss: 5.8578e-05 - val_mae: 0.0020
Epoch 459/700
150/150          1s 6ms/step -
loss: 8.0974e-05 - mae: 0.0043 - val_loss: 2.7658e-04 - val_mae: 0.0140
Epoch 460/700
150/150          1s 6ms/step -
loss: 6.9958e-05 - mae: 0.0031 - val_loss: 5.7050e-05 - val_mae: 0.0020
Epoch 461/700
150/150          1s 6ms/step -
loss: 6.1165e-05 - mae: 0.0025 - val_loss: 5.4334e-05 - val_mae: 0.0011
Epoch 462/700
150/150          1s 6ms/step -
loss: 5.4740e-05 - mae: 0.0012 - val_loss: 5.4080e-05 - val_mae: 0.0011
Epoch 463/700
150/150          1s 6ms/step -
loss: 8.2067e-05 - mae: 0.0037 - val_loss: 8.3795e-05 - val_mae: 0.0050
Epoch 464/700
150/150          1s 6ms/step -
loss: 1.1291e-04 - mae: 0.0060 - val_loss: 6.1973e-05 - val_mae: 0.0028
Epoch 465/700
150/150          1s 5ms/step -
loss: 6.2257e-05 - mae: 0.0026 - val_loss: 5.4865e-05 - val_mae: 0.0012
Epoch 466/700
150/150          1s 6ms/step -
loss: 5.3954e-05 - mae: 9.9623e-04 - val_loss: 5.3903e-05 - val_mae: 8.4706e-04
Epoch 467/700
150/150          1s 6ms/step -
loss: 5.9719e-05 - mae: 0.0021 - val_loss: 5.4549e-05 - val_mae: 0.0014
Epoch 468/700
150/150          1s 6ms/step -
loss: 5.9139e-05 - mae: 0.0022 - val_loss: 5.3877e-05 - val_mae: 0.0010
Epoch 469/700
150/150          1s 5ms/step -
loss: 6.3579e-05 - mae: 0.0027 - val_loss: 7.5397e-05 - val_mae: 0.0042
Epoch 470/700
150/150          1s 5ms/step -

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loss: 6.3700e-05 - mae: 0.0027 - val_loss: 5.4671e-05 - val_mae: 0.0013
Epoch 471/700
150/150          1s 6ms/step -
loss: 5.6546e-05 - mae: 0.0018 - val_loss: 9.4122e-05 - val_mae: 0.0063
Epoch 472/700
150/150          1s 5ms/step -
loss: 2.2647e-04 - mae: 0.0097 - val_loss: 5.4126e-05 - val_mae: 0.0011
Epoch 473/700
150/150          1s 5ms/step -
loss: 5.5509e-05 - mae: 0.0015 - val_loss: 6.5916e-05 - val_mae: 0.0034
Epoch 474/700
150/150          1s 6ms/step -
loss: 5.5559e-05 - mae: 0.0015 - val_loss: 5.4827e-05 - val_mae: 0.0015
Epoch 475/700
150/150          1s 6ms/step -
loss: 5.4175e-05 - mae: 0.0011 - val_loss: 5.6507e-05 - val_mae: 0.0018
Epoch 476/700
150/150          1s 5ms/step -
loss: 5.4770e-05 - mae: 0.0013 - val_loss: 5.5071e-05 - val_mae: 0.0013
Epoch 477/700
150/150          1s 5ms/step -
loss: 5.4835e-05 - mae: 0.0013 - val_loss: 5.7729e-05 - val_mae: 0.0020
Epoch 478/700
150/150          1s 5ms/step -
loss: 6.1555e-05 - mae: 0.0025 - val_loss: 5.5022e-05 - val_mae: 0.0015
Epoch 479/700
150/150          1s 6ms/step -
loss: 6.9492e-05 - mae: 0.0025 - val_loss: 1.2947e-04 - val_mae: 0.0082
Epoch 480/700
150/150          1s 5ms/step -
loss: 8.4917e-05 - mae: 0.0046 - val_loss: 5.3892e-05 - val_mae: 0.0011
Epoch 481/700
150/150          1s 5ms/step -
loss: 5.6093e-05 - mae: 0.0016 - val_loss: 5.7281e-05 - val_mae: 0.0022
Epoch 482/700
150/150          1s 5ms/step -
loss: 5.7756e-05 - mae: 0.0020 - val_loss: 6.5036e-05 - val_mae: 0.0030
Epoch 483/700
150/150          1s 5ms/step -
loss: 7.6913e-05 - mae: 0.0039 - val_loss: 1.1748e-04 - val_mae: 0.0074
Epoch 484/700
150/150          1s 5ms/step -
loss: 8.3069e-05 - mae: 0.0046 - val_loss: 5.4166e-05 - val_mae: 0.0012
Epoch 485/700
150/150          1s 5ms/step -
loss: 5.6846e-05 - mae: 0.0018 - val_loss: 5.7916e-05 - val_mae: 0.0021
Epoch 486/700
150/150          1s 5ms/step -

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loss: 5.9268e-05 - mae: 0.0021 - val_loss: 7.2669e-05 - val_mae: 0.0039
Epoch 487/700
150/150          1s 6ms/step -
loss: 1.0816e-04 - mae: 0.0061 - val_loss: 7.3166e-05 - val_mae: 0.0046
Epoch 488/700
150/150          1s 5ms/step -
loss: 5.8106e-05 - mae: 0.0019 - val_loss: 1.7560e-04 - val_mae: 0.0097
Epoch 489/700
150/150          1s 5ms/step -
loss: 6.9119e-05 - mae: 0.0033 - val_loss: 6.6971e-05 - val_mae: 0.0037
Epoch 490/700
150/150          1s 5ms/step -
loss: 5.9640e-05 - mae: 0.0023 - val_loss: 5.5824e-05 - val_mae: 0.0016
Epoch 491/700
150/150          1s 6ms/step -
loss: 5.9472e-05 - mae: 0.0023 - val_loss: 5.5223e-05 - val_mae: 0.0015
Epoch 492/700
150/150          1s 5ms/step -
loss: 6.2657e-05 - mae: 0.0027 - val_loss: 5.7323e-05 - val_mae: 0.0022
Epoch 493/700
150/150          1s 5ms/step -
loss: 5.4632e-05 - mae: 0.0013 - val_loss: 1.6577e-04 - val_mae: 0.0104
Epoch 494/700
150/150          1s 5ms/step -
loss: 7.9908e-05 - mae: 0.0043 - val_loss: 5.9438e-05 - val_mae: 0.0023
Epoch 495/700
150/150          1s 5ms/step -
loss: 8.0583e-05 - mae: 0.0044 - val_loss: 7.4376e-05 - val_mae: 0.0043
Epoch 496/700
150/150          1s 5ms/step -
loss: 6.8189e-05 - mae: 0.0033 - val_loss: 1.4755e-04 - val_mae: 0.0096
Epoch 497/700
150/150          1s 5ms/step -
loss: 7.7488e-05 - mae: 0.0038 - val_loss: 9.3134e-05 - val_mae: 0.0062
Epoch 498/700
150/150          1s 5ms/step -
loss: 5.6917e-05 - mae: 0.0018 - val_loss: 5.4708e-05 - val_mae: 0.0014
Epoch 499/700
150/150          1s 5ms/step -
loss: 1.1061e-04 - mae: 0.0041 - val_loss: 7.9015e-04 - val_mae: 0.0227
Epoch 500/700
150/150          1s 5ms/step -
loss: 2.1806e-04 - mae: 0.0078 - val_loss: 5.7393e-05 - val_mae: 0.0020
Epoch 501/700
150/150          1s 5ms/step -
loss: 5.3944e-05 - mae: 0.0011 - val_loss: 5.3365e-05 - val_mae: 7.2415e-04
Epoch 502/700

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150/150                    1s 6ms/step -  
 loss: 5.3644e-05 - mae: 9.3295e-04 - val\_loss: 5.4108e-05 - val\_mae: 9.6299e-04  
 Epoch 503/700  
 150/150                    1s 5ms/step -  
 loss: 5.3513e-05 - mae: 9.0440e-04 - val\_loss: 5.3303e-05 - val\_mae: 7.4973e-04  
 Epoch 504/700  
 150/150                    1s 5ms/step -  
 loss: 5.3794e-05 - mae: 0.0010 - val\_loss: 5.4282e-05 - val\_mae: 0.0012  
 Epoch 505/700  
 150/150                    1s 5ms/step -  
 loss: 5.3806e-05 - mae: 0.0011 - val\_loss: 5.6377e-05 - val\_mae: 0.0018  
 Epoch 506/700  
 150/150                    1s 6ms/step -  
 loss: 5.4300e-05 - mae: 0.0012 - val\_loss: 5.9649e-05 - val\_mae: 0.0025  
 Epoch 507/700  
 150/150                    1s 5ms/step -  
 loss: 5.4780e-05 - mae: 0.0014 - val\_loss: 5.7162e-05 - val\_mae: 0.0016  
 Epoch 508/700  
 150/150                    1s 6ms/step -  
 loss: 5.3852e-05 - mae: 0.0011 - val\_loss: 5.5723e-05 - val\_mae: 0.0016  
 Epoch 509/700  
 150/150                    1s 5ms/step -  
 loss: 5.8393e-05 - mae: 0.0021 - val\_loss: 5.5271e-05 - val\_mae: 0.0014  
 Epoch 510/700  
 150/150                    1s 5ms/step -  
 loss: 6.7390e-05 - mae: 0.0029 - val\_loss: 5.3585e-05 - val\_mae: 9.0502e-04  
 Epoch 511/700  
 150/150                    1s 5ms/step -  
 loss: 5.8916e-05 - mae: 0.0022 - val\_loss: 6.5079e-05 - val\_mae: 0.0034  
 Epoch 512/700  
 150/150                    1s 5ms/step -  
 loss: 6.7380e-05 - mae: 0.0032 - val\_loss: 7.2542e-05 - val\_mae: 0.0041  
 Epoch 513/700  
 150/150                    1s 5ms/step -  
 loss: 1.2608e-04 - mae: 0.0066 - val\_loss: 7.3059e-05 - val\_mae: 0.0036  
 Epoch 514/700  
 150/150                    1s 5ms/step -  
 loss: 5.9532e-05 - mae: 0.0021 - val\_loss: 6.1087e-05 - val\_mae: 0.0028  
 Epoch 515/700  
 150/150                    1s 5ms/step -  
 loss: 5.7996e-05 - mae: 0.0020 - val\_loss: 5.3371e-05 - val\_mae: 8.8726e-04  
 Epoch 516/700  
 150/150                    1s 5ms/step -  
 loss: 5.6076e-05 - mae: 0.0016 - val\_loss: 6.1828e-05 - val\_mae: 0.0027  
 Epoch 517/700  
 150/150                    1s 5ms/step -  
 loss: 7.4097e-05 - mae: 0.0036 - val\_loss: 8.5322e-05 - val\_mae: 0.0056  
 Epoch 518/700

150/150                    1s 5ms/step -  
 loss: 6.0241e-05 - mae: 0.0023 - val\_loss: 5.8560e-05 - val\_mae: 0.0021  
 Epoch 519/700  
 150/150                    1s 5ms/step -  
 loss: 6.4610e-05 - mae: 0.0029 - val\_loss: 5.3739e-05 - val\_mae: 0.0010  
 Epoch 520/700  
 150/150                    1s 5ms/step -  
 loss: 5.5226e-05 - mae: 0.0015 - val\_loss: 5.8079e-05 - val\_mae: 0.0022  
 Epoch 521/700  
 150/150                    1s 5ms/step -  
 loss: 7.5029e-05 - mae: 0.0038 - val\_loss: 5.3056e-05 - val\_mae: 7.6015e-04  
 Epoch 522/700  
 150/150                    1s 5ms/step -  
 loss: 5.5062e-05 - mae: 0.0014 - val\_loss: 1.0743e-04 - val\_mae: 0.0063  
 Epoch 523/700  
 150/150                    1s 5ms/step -  
 loss: 8.8247e-05 - mae: 0.0048 - val\_loss: 5.9839e-05 - val\_mae: 0.0024  
 Epoch 524/700  
 150/150                    1s 5ms/step -  
 loss: 6.7777e-05 - mae: 0.0032 - val\_loss: 5.8628e-05 - val\_mae: 0.0023  
 Epoch 525/700  
 150/150                    1s 5ms/step -  
 loss: 9.0868e-05 - mae: 0.0050 - val\_loss: 6.0995e-05 - val\_mae: 0.0026  
 Epoch 526/700  
 150/150                    1s 6ms/step -  
 loss: 5.4811e-05 - mae: 0.0014 - val\_loss: 5.4655e-05 - val\_mae: 0.0013  
 Epoch 527/700  
 150/150                    1s 5ms/step -  
 loss: 5.5456e-05 - mae: 0.0016 - val\_loss: 5.3296e-05 - val\_mae: 9.8911e-04  
 Epoch 528/700  
 150/150                    1s 5ms/step -  
 loss: 5.4582e-05 - mae: 0.0014 - val\_loss: 5.9119e-05 - val\_mae: 0.0028  
 Epoch 529/700  
 150/150                    1s 5ms/step -  
 loss: 5.8657e-05 - mae: 0.0022 - val\_loss: 5.3957e-05 - val\_mae: 0.0011  
 Epoch 530/700  
 150/150                    1s 5ms/step -  
 loss: 6.6560e-05 - mae: 0.0030 - val\_loss: 9.5727e-05 - val\_mae: 0.0054  
 Epoch 531/700  
 150/150                    1s 5ms/step -  
 loss: 1.1679e-04 - mae: 0.0058 - val\_loss: 5.5013e-05 - val\_mae: 0.0013  
 Epoch 532/700  
 150/150                    1s 6ms/step -  
 loss: 5.4068e-05 - mae: 0.0012 - val\_loss: 5.3159e-05 - val\_mae: 9.3177e-04  
 Epoch 533/700  
 150/150                    1s 7ms/step -  
 loss: 5.6739e-05 - mae: 0.0018 - val\_loss: 6.2426e-05 - val\_mae: 0.0031  
 Epoch 534/700

150/150                    1s 5ms/step -  
 loss: 5.7889e-05 - mae: 0.0020 - val\_loss: 5.5954e-05 - val\_mae: 0.0018  
 Epoch 535/700  
 150/150                    1s 7ms/step -  
 loss: 7.4803e-05 - mae: 0.0034 - val\_loss: 5.3967e-05 - val\_mae: 0.0013  
 Epoch 536/700  
 150/150                    1s 5ms/step -  
 loss: 5.6130e-05 - mae: 0.0017 - val\_loss: 5.5954e-05 - val\_mae: 0.0019  
 Epoch 537/700  
 150/150                    1s 5ms/step -  
 loss: 1.0511e-04 - mae: 0.0055 - val\_loss: 5.9122e-05 - val\_mae: 0.0023  
 Epoch 538/700  
 150/150                    1s 5ms/step -  
 loss: 8.4014e-05 - mae: 0.0044 - val\_loss: 5.4145e-05 - val\_mae: 0.0014  
 Epoch 539/700  
 150/150                    1s 5ms/step -  
 loss: 5.9055e-05 - mae: 0.0022 - val\_loss: 8.2517e-05 - val\_mae: 0.0053  
 Epoch 540/700  
 150/150                    1s 5ms/step -  
 loss: 5.6960e-05 - mae: 0.0020 - val\_loss: 5.3768e-05 - val\_mae: 0.0012  
 Epoch 541/700  
 150/150                    1s 5ms/step -  
 loss: 5.5671e-05 - mae: 0.0016 - val\_loss: 1.1446e-04 - val\_mae: 0.0073  
 Epoch 542/700  
 150/150                    1s 5ms/step -  
 loss: 6.8121e-05 - mae: 0.0033 - val\_loss: 1.1142e-04 - val\_mae: 0.0066  
 Epoch 543/700  
 150/150                    1s 5ms/step -  
 loss: 7.6640e-05 - mae: 0.0040 - val\_loss: 6.1202e-05 - val\_mae: 0.0027  
 Epoch 544/700  
 150/150                    1s 5ms/step -  
 loss: 6.7840e-05 - mae: 0.0033 - val\_loss: 6.1065e-05 - val\_mae: 0.0027  
 Epoch 545/700  
 150/150                    1s 5ms/step -  
 loss: 7.3228e-05 - mae: 0.0037 - val\_loss: 8.8774e-05 - val\_mae: 0.0051  
 Epoch 546/700  
 150/150                    1s 5ms/step -  
 loss: 8.2387e-05 - mae: 0.0044 - val\_loss: 5.7156e-05 - val\_mae: 0.0021  
 Epoch 547/700  
 150/150                    1s 5ms/step -  
 loss: 5.5527e-05 - mae: 0.0015 - val\_loss: 8.5837e-05 - val\_mae: 0.0046  
 Epoch 548/700  
 150/150                    1s 5ms/step -  
 loss: 6.2372e-05 - mae: 0.0027 - val\_loss: 6.8567e-05 - val\_mae: 0.0035  
 Epoch 549/700  
 150/150                    1s 5ms/step -  
 loss: 7.3878e-05 - mae: 0.0037 - val\_loss: 5.4531e-05 - val\_mae: 0.0014  
 Epoch 550/700

150/150                    1s 5ms/step -  
 loss: 6.0389e-05 - mae: 0.0023 - val\_loss: 6.7778e-05 - val\_mae: 0.0039  
 Epoch 551/700

150/150                    1s 5ms/step -  
 loss: 1.0322e-04 - mae: 0.0056 - val\_loss: 6.9157e-05 - val\_mae: 0.0040  
 Epoch 552/700

150/150                    1s 5ms/step -  
 loss: 5.9464e-05 - mae: 0.0023 - val\_loss: 5.3894e-05 - val\_mae: 0.0010  
 Epoch 553/700

150/150                    1s 6ms/step -  
 loss: 5.3689e-05 - mae: 0.0012 - val\_loss: 5.6990e-05 - val\_mae: 0.0022  
 Epoch 554/700

150/150                    1s 5ms/step -  
 loss: 5.5029e-05 - mae: 0.0015 - val\_loss: 5.3960e-05 - val\_mae: 0.0014  
 Epoch 555/700

150/150                    1s 6ms/step -  
 loss: 5.7131e-05 - mae: 0.0019 - val\_loss: 6.4101e-05 - val\_mae: 0.0034  
 Epoch 556/700

150/150                    1s 5ms/step -  
 loss: 6.8263e-05 - mae: 0.0033 - val\_loss: 9.4610e-05 - val\_mae: 0.0057  
 Epoch 557/700

150/150                    1s 5ms/step -  
 loss: 7.2910e-05 - mae: 0.0037 - val\_loss: 0.0013 - val\_mae: 0.0339  
 Epoch 558/700

150/150                    1s 5ms/step -  
 loss: 1.5478e-04 - mae: 0.0073 - val\_loss: 5.5229e-05 - val\_mae: 0.0017  
 Epoch 559/700

150/150                    1s 5ms/step -  
 loss: 5.5652e-05 - mae: 0.0016 - val\_loss: 5.3590e-05 - val\_mae: 0.0012  
 Epoch 560/700

150/150                    1s 5ms/step -  
 loss: 5.5861e-05 - mae: 0.0017 - val\_loss: 6.7565e-05 - val\_mae: 0.0036  
 Epoch 561/700

150/150                    1s 5ms/step -  
 loss: 5.9791e-05 - mae: 0.0024 - val\_loss: 6.2096e-05 - val\_mae: 0.0028  
 Epoch 562/700

150/150                    1s 5ms/step -  
 loss: 6.3856e-05 - mae: 0.0024 - val\_loss: 8.7046e-05 - val\_mae: 0.0053  
 Epoch 563/700

150/150                    1s 5ms/step -  
 loss: 1.1399e-04 - mae: 0.0060 - val\_loss: 5.6128e-05 - val\_mae: 0.0020  
 Epoch 564/700

150/150                    1s 5ms/step -  
 loss: 5.8391e-05 - mae: 0.0017 - val\_loss: 5.5246e-05 - val\_mae: 0.0016  
 Epoch 565/700

150/150                    1s 5ms/step -  
 loss: 7.9958e-05 - mae: 0.0042 - val\_loss: 5.3694e-05 - val\_mae: 0.0013

Epoch 566/700  
150/150 1s 5ms/step -  
loss: 5.6535e-05 - mae: 0.0019 - val\_loss: 5.5080e-05 - val\_mae: 0.0018

Epoch 567/700  
150/150 1s 6ms/step -  
loss: 5.6840e-05 - mae: 0.0019 - val\_loss: 5.5113e-05 - val\_mae: 0.0016

Epoch 568/700  
150/150 1s 5ms/step -  
loss: 1.0663e-04 - mae: 0.0041 - val\_loss: 6.3071e-05 - val\_mae: 0.0030

Epoch 569/700  
150/150 1s 5ms/step -  
loss: 5.6731e-05 - mae: 0.0019 - val\_loss: 5.4987e-05 - val\_mae: 0.0017

Epoch 570/700  
150/150 1s 5ms/step -  
loss: 5.3381e-05 - mae: 0.0011 - val\_loss: 5.3760e-05 - val\_mae: 0.0011

Epoch 571/700  
150/150 1s 5ms/step -  
loss: 5.3231e-05 - mae: 0.0011 - val\_loss: 5.3385e-05 - val\_mae: 8.2897e-04

Epoch 572/700  
150/150 1s 5ms/step -  
loss: 5.3127e-05 - mae: 9.9653e-04 - val\_loss: 5.9181e-05 - val\_mae: 0.0026

Epoch 573/700  
150/150 1s 5ms/step -  
loss: 1.2470e-04 - mae: 0.0057 - val\_loss: 5.3755e-05 - val\_mae: 0.0012

Epoch 574/700  
150/150 1s 5ms/step -  
loss: 5.3563e-05 - mae: 0.0012 - val\_loss: 5.3190e-05 - val\_mae: 0.0010

Epoch 575/700  
150/150 1s 5ms/step -  
loss: 5.4616e-05 - mae: 0.0015 - val\_loss: 5.6405e-05 - val\_mae: 0.0022

Epoch 576/700  
150/150 1s 5ms/step -  
loss: 5.3939e-05 - mae: 0.0013 - val\_loss: 5.5112e-05 - val\_mae: 0.0019

Epoch 577/700  
150/150 1s 5ms/step -  
loss: 5.3498e-05 - mae: 0.0012 - val\_loss: 5.3047e-05 - val\_mae: 9.7087e-04

Epoch 578/700  
150/150 1s 5ms/step -  
loss: 5.5981e-05 - mae: 0.0018 - val\_loss: 5.4505e-05 - val\_mae: 0.0014

Epoch 579/700  
150/150 1s 5ms/step -  
loss: 5.6664e-05 - mae: 0.0018 - val\_loss: 9.2640e-05 - val\_mae: 0.0061

Epoch 580/700  
150/150 1s 5ms/step -  
loss: 9.7833e-05 - mae: 0.0043 - val\_loss: 5.7457e-05 - val\_mae: 0.0020

Epoch 581/700  
150/150 1s 5ms/step -  
loss: 5.6010e-05 - mae: 0.0017 - val\_loss: 7.8440e-05 - val\_mae: 0.0046

Epoch 582/700  
150/150 1s 5ms/step -  
loss: 5.5300e-05 - mae: 0.0015 - val\_loss: 5.3576e-05 - val\_mae: 0.0012  
Epoch 583/700  
150/150 1s 5ms/step -  
loss: 5.4678e-05 - mae: 0.0015 - val\_loss: 5.5667e-05 - val\_mae: 0.0021  
Epoch 584/700  
150/150 1s 5ms/step -  
loss: 6.0281e-05 - mae: 0.0022 - val\_loss: 9.3194e-05 - val\_mae: 0.0061  
Epoch 585/700  
150/150 1s 5ms/step -  
loss: 7.0760e-05 - mae: 0.0036 - val\_loss: 7.0128e-05 - val\_mae: 0.0040  
Epoch 586/700  
150/150 1s 5ms/step -  
loss: 5.5476e-05 - mae: 0.0016 - val\_loss: 6.0250e-05 - val\_mae: 0.0028  
Epoch 587/700  
150/150 1s 5ms/step -  
loss: 8.9958e-05 - mae: 0.0047 - val\_loss: 8.2707e-05 - val\_mae: 0.0054  
Epoch 588/700  
150/150 1s 6ms/step -  
loss: 6.2646e-05 - mae: 0.0028 - val\_loss: 5.6860e-05 - val\_mae: 0.0022  
Epoch 589/700  
150/150 1s 5ms/step -  
loss: 7.1744e-05 - mae: 0.0036 - val\_loss: 5.4576e-05 - val\_mae: 0.0016  
Epoch 590/700  
150/150 1s 5ms/step -  
loss: 5.8005e-05 - mae: 0.0021 - val\_loss: 5.7562e-05 - val\_mae: 0.0021  
Epoch 591/700  
150/150 1s 5ms/step -  
loss: 5.4695e-05 - mae: 0.0015 - val\_loss: 5.3840e-05 - val\_mae: 0.0014  
Epoch 592/700  
150/150 1s 5ms/step -  
loss: 7.5828e-05 - mae: 0.0036 - val\_loss: 4.0078e-04 - val\_mae: 0.0177  
Epoch 593/700  
150/150 1s 5ms/step -  
loss: 1.3788e-04 - mae: 0.0066 - val\_loss: 5.5287e-05 - val\_mae: 0.0018  
Epoch 594/700  
150/150 1s 5ms/step -  
loss: 5.6941e-05 - mae: 0.0020 - val\_loss: 5.3507e-05 - val\_mae: 0.0013  
Epoch 595/700  
150/150 1s 5ms/step -  
loss: 5.3215e-05 - mae: 0.0011 - val\_loss: 5.2538e-05 - val\_mae: 7.7217e-04  
Epoch 596/700  
150/150 1s 5ms/step -  
loss: 6.7043e-05 - mae: 0.0026 - val\_loss: 5.7516e-05 - val\_mae: 0.0021  
Epoch 597/700  
150/150 1s 5ms/step -  
loss: 5.9710e-05 - mae: 0.0024 - val\_loss: 5.3080e-05 - val\_mae: 0.0011

Epoch 598/700  
150/150 1s 5ms/step -  
loss: 5.9061e-05 - mae: 0.0024 - val\_loss: 6.1990e-05 - val\_mae: 0.0030  
Epoch 599/700  
150/150 1s 6ms/step -  
loss: 5.7111e-05 - mae: 0.0020 - val\_loss: 5.8206e-05 - val\_mae: 0.0023  
Epoch 600/700  
150/150 1s 5ms/step -  
loss: 8.9626e-05 - mae: 0.0042 - val\_loss: 5.3787e-05 - val\_mae: 0.0012  
Epoch 601/700  
150/150 1s 5ms/step -  
loss: 5.4991e-05 - mae: 0.0016 - val\_loss: 5.5019e-05 - val\_mae: 0.0014  
Epoch 602/700  
150/150 1s 5ms/step -  
loss: 5.9932e-05 - mae: 0.0020 - val\_loss: 1.5857e-04 - val\_mae: 0.0091  
Epoch 603/700  
150/150 1s 5ms/step -  
loss: 7.4205e-05 - mae: 0.0036 - val\_loss: 5.3390e-05 - val\_mae: 0.0013  
Epoch 604/700  
150/150 1s 5ms/step -  
loss: 5.6530e-05 - mae: 0.0017 - val\_loss: 7.2438e-05 - val\_mae: 0.0041  
Epoch 605/700  
150/150 1s 5ms/step -  
loss: 6.2983e-05 - mae: 0.0029 - val\_loss: 5.5328e-05 - val\_mae: 0.0017  
Epoch 606/700  
150/150 1s 5ms/step -  
loss: 9.3106e-05 - mae: 0.0043 - val\_loss: 5.2733e-05 - val\_mae: 9.2278e-04  
Epoch 607/700  
150/150 1s 6ms/step -  
loss: 5.5283e-05 - mae: 0.0017 - val\_loss: 5.6675e-05 - val\_mae: 0.0022  
Epoch 608/700  
150/150 1s 5ms/step -  
loss: 5.4814e-05 - mae: 0.0016 - val\_loss: 5.5387e-05 - val\_mae: 0.0018  
Epoch 609/700  
150/150 1s 5ms/step -  
loss: 6.2140e-05 - mae: 0.0028 - val\_loss: 1.0137e-04 - val\_mae: 0.0069  
Epoch 610/700  
150/150 1s 5ms/step -  
loss: 6.6930e-05 - mae: 0.0032 - val\_loss: 5.8701e-05 - val\_mae: 0.0025  
Epoch 611/700  
150/150 1s 5ms/step -  
loss: 1.1482e-04 - mae: 0.0055 - val\_loss: 5.7120e-05 - val\_mae: 0.0021  
Epoch 612/700  
150/150 1s 5ms/step -  
loss: 6.3937e-05 - mae: 0.0027 - val\_loss: 7.6765e-05 - val\_mae: 0.0048  
Epoch 613/700  
150/150 1s 5ms/step -

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loss: 6.0746e-05 - mae: 0.0024 - val_loss: 5.9130e-05 - val_mae: 0.0024
Epoch 614/700
150/150          1s 5ms/step -
loss: 5.5627e-05 - mae: 0.0018 - val_loss: 5.4080e-05 - val_mae: 0.0016
Epoch 615/700
150/150          1s 5ms/step -
loss: 6.3173e-05 - mae: 0.0028 - val_loss: 5.9619e-05 - val_mae: 0.0025
Epoch 616/700
150/150          1s 6ms/step -
loss: 8.5945e-05 - mae: 0.0047 - val_loss: 6.0152e-05 - val_mae: 0.0027
Epoch 617/700
150/150          1s 6ms/step -
loss: 6.1044e-05 - mae: 0.0025 - val_loss: 5.3088e-05 - val_mae: 0.0012
Epoch 618/700
150/150          1s 5ms/step -
loss: 7.0549e-05 - mae: 0.0032 - val_loss: 5.5745e-05 - val_mae: 0.0021
Epoch 619/700
150/150          1s 5ms/step -
loss: 5.6739e-05 - mae: 0.0020 - val_loss: 5.2563e-05 - val_mae: 9.5247e-04
Epoch 620/700
150/150          1s 5ms/step -
loss: 1.0495e-04 - mae: 0.0047 - val_loss: 5.3569e-05 - val_mae: 0.0014
Epoch 621/700
150/150          1s 5ms/step -
loss: 5.8384e-05 - mae: 0.0023 - val_loss: 6.0203e-05 - val_mae: 0.0027
Epoch 622/700
150/150          1s 5ms/step -
loss: 5.6542e-05 - mae: 0.0019 - val_loss: 6.8673e-05 - val_mae: 0.0037
Epoch 623/700
150/150          1s 5ms/step -
loss: 8.1347e-05 - mae: 0.0045 - val_loss: 7.3253e-05 - val_mae: 0.0038
Epoch 624/700
150/150          1s 5ms/step -
loss: 6.2604e-05 - mae: 0.0027 - val_loss: 5.3479e-05 - val_mae: 0.0013
Epoch 625/700
150/150          1s 5ms/step -
loss: 5.4784e-05 - mae: 0.0016 - val_loss: 5.3376e-05 - val_mae: 0.0014
Epoch 626/700
150/150          1s 5ms/step -
loss: 6.4690e-05 - mae: 0.0020 - val_loss: 0.0018 - val_mae: 0.0370
Epoch 627/700
150/150          1s 5ms/step -
loss: 2.2941e-04 - mae: 0.0087 - val_loss: 5.5138e-05 - val_mae: 0.0019
Epoch 628/700
150/150          1s 6ms/step -
loss: 5.2989e-05 - mae: 0.0011 - val_loss: 5.3182e-05 - val_mae: 0.0013
Epoch 629/700
150/150          1s 6ms/step -

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loss: 5.3095e-05 - mae: 0.0012 - val_loss: 5.9679e-05 - val_mae: 0.0025
Epoch 630/700
150/150          1s 5ms/step -
loss: 5.4587e-05 - mae: 0.0015 - val_loss: 5.8914e-05 - val_mae: 0.0027
Epoch 631/700
150/150          1s 5ms/step -
loss: 5.4182e-05 - mae: 0.0015 - val_loss: 7.2784e-05 - val_mae: 0.0040
Epoch 632/700
150/150          1s 5ms/step -
loss: 6.7315e-05 - mae: 0.0032 - val_loss: 2.4382e-04 - val_mae: 0.0136
Epoch 633/700
150/150          1s 5ms/step -
loss: 6.9850e-05 - mae: 0.0034 - val_loss: 5.3316e-05 - val_mae: 0.0014
Epoch 634/700
150/150          1s 5ms/step -
loss: 5.6579e-05 - mae: 0.0019 - val_loss: 5.2735e-05 - val_mae: 0.0011
Epoch 635/700
150/150          1s 5ms/step -
loss: 5.4605e-05 - mae: 0.0016 - val_loss: 7.5173e-05 - val_mae: 0.0047
Epoch 636/700
150/150          1s 5ms/step -
loss: 5.5286e-05 - mae: 0.0017 - val_loss: 5.4652e-05 - val_mae: 0.0014
Epoch 637/700
150/150          1s 5ms/step -
loss: 6.2862e-05 - mae: 0.0023 - val_loss: 6.2278e-05 - val_mae: 0.0030
Epoch 638/700
150/150          1s 5ms/step -
loss: 9.9601e-05 - mae: 0.0055 - val_loss: 5.6945e-05 - val_mae: 0.0021
Epoch 639/700
150/150          1s 5ms/step -
loss: 5.7268e-05 - mae: 0.0022 - val_loss: 5.5406e-05 - val_mae: 0.0017
Epoch 640/700
150/150          1s 5ms/step -
loss: 5.6513e-05 - mae: 0.0020 - val_loss: 5.4842e-05 - val_mae: 0.0018
Epoch 641/700
150/150          1s 5ms/step -
loss: 5.6502e-05 - mae: 0.0020 - val_loss: 5.2639e-05 - val_mae: 0.0012
Epoch 642/700
150/150          1s 5ms/step -
loss: 6.3523e-05 - mae: 0.0026 - val_loss: 5.6151e-05 - val_mae: 0.0022
Epoch 643/700
150/150          1s 5ms/step -
loss: 6.8851e-05 - mae: 0.0033 - val_loss: 1.2929e-04 - val_mae: 0.0087
Epoch 644/700
150/150          1s 5ms/step -
loss: 6.5885e-05 - mae: 0.0027 - val_loss: 6.8111e-05 - val_mae: 0.0034
Epoch 645/700
150/150          1s 5ms/step -

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loss: 6.8696e-05 - mae: 0.0034 - val_loss: 5.2925e-05 - val_mae: 8.0005e-04
Epoch 646/700
150/150          1s 5ms/step -
loss: 5.4293e-05 - mae: 0.0014 - val_loss: 5.3751e-05 - val_mae: 0.0016
Epoch 647/700
150/150          1s 5ms/step -
loss: 5.4509e-05 - mae: 0.0017 - val_loss: 6.3398e-05 - val_mae: 0.0031
Epoch 648/700
150/150          1s 5ms/step -
loss: 5.7190e-05 - mae: 0.0021 - val_loss: 5.3871e-05 - val_mae: 0.0015
Epoch 649/700
150/150          1s 5ms/step -
loss: 5.8463e-05 - mae: 0.0020 - val_loss: 2.5529e-04 - val_mae: 0.0123
Epoch 650/700
150/150          1s 5ms/step -
loss: 8.2964e-05 - mae: 0.0043 - val_loss: 7.7045e-05 - val_mae: 0.0044
Epoch 651/700
150/150          1s 5ms/step -
loss: 1.6474e-04 - mae: 0.0081 - val_loss: 5.6657e-05 - val_mae: 0.0022
Epoch 652/700
150/150          1s 5ms/step -
loss: 5.3255e-05 - mae: 0.0013 - val_loss: 5.1986e-05 - val_mae: 7.8623e-04
Epoch 653/700
150/150          1s 7ms/step -
loss: 5.2858e-05 - mae: 0.0011 - val_loss: 5.3540e-05 - val_mae: 0.0012
Epoch 654/700
150/150          1s 6ms/step -
loss: 5.2481e-05 - mae: 0.0010 - val_loss: 6.2709e-05 - val_mae: 0.0031
Epoch 655/700
150/150          1s 5ms/step -
loss: 5.7442e-05 - mae: 0.0022 - val_loss: 7.3898e-05 - val_mae: 0.0045
Epoch 656/700
150/150          1s 5ms/step -
loss: 6.7154e-05 - mae: 0.0034 - val_loss: 6.3239e-05 - val_mae: 0.0028
Epoch 657/700
150/150          1s 5ms/step -
loss: 6.1501e-05 - mae: 0.0027 - val_loss: 1.0113e-04 - val_mae: 0.0059
Epoch 658/700
150/150          1s 5ms/step -
loss: 1.1578e-04 - mae: 0.0066 - val_loss: 6.2897e-05 - val_mae: 0.0031
Epoch 659/700
150/150          1s 5ms/step -
loss: 5.7138e-05 - mae: 0.0020 - val_loss: 5.5856e-05 - val_mae: 0.0016
Epoch 660/700
150/150          1s 5ms/step -
loss: 5.8542e-05 - mae: 0.0023 - val_loss: 1.5769e-04 - val_mae: 0.0097
Epoch 661/700

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150/150          1s 5ms/step -
loss: 6.7896e-05 - mae: 0.0032 - val_loss: 5.5602e-05 - val_mae: 0.0020
Epoch 662/700
150/150          1s 5ms/step -
loss: 6.2090e-05 - mae: 0.0026 - val_loss: 6.0013e-05 - val_mae: 0.0027
Epoch 663/700
150/150          1s 6ms/step -
loss: 5.6052e-05 - mae: 0.0020 - val_loss: 5.3942e-05 - val_mae: 0.0016
Epoch 664/700
150/150          1s 5ms/step -
loss: 1.0083e-04 - mae: 0.0056 - val_loss: 9.3592e-05 - val_mae: 0.0063
Epoch 665/700
150/150          1s 5ms/step -
loss: 6.1425e-05 - mae: 0.0028 - val_loss: 5.2903e-05 - val_mae: 0.0011
Epoch 666/700
150/150          1s 5ms/step -
loss: 5.7591e-05 - mae: 0.0020 - val_loss: 1.2629e-04 - val_mae: 0.0085
Epoch 667/700
150/150          1s 5ms/step -
loss: 6.3564e-05 - mae: 0.0029 - val_loss: 1.6755e-04 - val_mae: 0.0104
Epoch 668/700
150/150          1s 5ms/step -
loss: 1.2516e-04 - mae: 0.0070 - val_loss: 5.2774e-05 - val_mae: 0.0012
Epoch 669/700
150/150          1s 5ms/step -
loss: 6.0947e-05 - mae: 0.0025 - val_loss: 6.0841e-05 - val_mae: 0.0027
Epoch 670/700
150/150          1s 5ms/step -
loss: 7.3681e-05 - mae: 0.0037 - val_loss: 5.4966e-05 - val_mae: 0.0018
Epoch 671/700
150/150          1s 5ms/step -
loss: 5.3747e-05 - mae: 0.0015 - val_loss: 5.6032e-05 - val_mae: 0.0020
Epoch 672/700
150/150          1s 5ms/step -
loss: 5.4388e-05 - mae: 0.0016 - val_loss: 5.2361e-05 - val_mae: 0.0012
Epoch 673/700
150/150          1s 5ms/step -
loss: 5.5563e-05 - mae: 0.0017 - val_loss: 5.8638e-05 - val_mae: 0.0023
Epoch 674/700
150/150          1s 5ms/step -
loss: 1.0229e-04 - mae: 0.0053 - val_loss: 5.8613e-05 - val_mae: 0.0020
Epoch 675/700
150/150          1s 5ms/step -
loss: 1.1558e-04 - mae: 0.0056 - val_loss: 5.8150e-05 - val_mae: 0.0022
Epoch 676/700
150/150          1s 5ms/step -
loss: 5.3396e-05 - mae: 0.0013 - val_loss: 5.2274e-05 - val_mae: 0.0011
Epoch 677/700

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150/150                    1s 5ms/step -  
 loss: 5.3264e-05 - mae: 0.0013 - val\_loss: 5.2239e-05 - val\_mae: 9.1470e-04  
 Epoch 678/700  
 150/150                    1s 6ms/step -  
 loss: 5.3149e-05 - mae: 0.0013 - val\_loss: 7.1510e-05 - val\_mae: 0.0045  
 Epoch 679/700  
 150/150                    1s 6ms/step -  
 loss: 5.7293e-05 - mae: 0.0022 - val\_loss: 5.7036e-05 - val\_mae: 0.0024  
 Epoch 680/700  
 150/150                    1s 6ms/step -  
 loss: 6.2817e-05 - mae: 0.0027 - val\_loss: 5.4617e-05 - val\_mae: 0.0018  
 Epoch 681/700  
 150/150                    1s 5ms/step -  
 loss: 5.6677e-05 - mae: 0.0021 - val\_loss: 5.5729e-05 - val\_mae: 0.0021  
 Epoch 682/700  
 150/150                    1s 5ms/step -  
 loss: 1.1012e-04 - mae: 0.0062 - val\_loss: 7.0674e-05 - val\_mae: 0.0041  
 Epoch 683/700  
 150/150                    1s 6ms/step -  
 loss: 6.5224e-05 - mae: 0.0032 - val\_loss: 5.2441e-05 - val\_mae: 0.0010  
 Epoch 684/700  
 150/150                    1s 6ms/step -  
 loss: 5.2703e-05 - mae: 0.0012 - val\_loss: 5.2964e-05 - val\_mae: 0.0013  
 Epoch 685/700  
 150/150                    1s 9ms/step -  
 loss: 5.3545e-05 - mae: 0.0015 - val\_loss: 6.2456e-05 - val\_mae: 0.0032  
 Epoch 686/700  
 150/150                    1s 7ms/step -  
 loss: 5.4148e-05 - mae: 0.0016 - val\_loss: 5.4225e-05 - val\_mae: 0.0016  
 Epoch 687/700  
 150/150                    1s 9ms/step -  
 loss: 5.7671e-05 - mae: 0.0017 - val\_loss: 5.4024e-05 - val\_mae: 0.0017  
 Epoch 688/700  
 150/150                    1s 7ms/step -  
 loss: 5.5817e-05 - mae: 0.0019 - val\_loss: 5.6376e-05 - val\_mae: 0.0020  
 Epoch 689/700  
 150/150                    1s 6ms/step -  
 loss: 6.3720e-05 - mae: 0.0023 - val\_loss: 5.5986e-04 - val\_mae: 0.0212  
 Epoch 690/700  
 150/150                    1s 6ms/step -  
 loss: 1.3221e-04 - mae: 0.0064 - val\_loss: 5.4347e-05 - val\_mae: 0.0016  
 Epoch 691/700  
 150/150                    1s 5ms/step -  
 loss: 5.4612e-05 - mae: 0.0017 - val\_loss: 5.2093e-05 - val\_mae: 8.7591e-04  
 Epoch 692/700  
 150/150                    1s 5ms/step -  
 loss: 7.9632e-05 - mae: 0.0039 - val\_loss: 6.0561e-05 - val\_mae: 0.0029  
 Epoch 693/700

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150/150          1s 6ms/step -
loss: 5.5756e-05 - mae: 0.0018 - val_loss: 5.5234e-05 - val_mae: 0.0019
Epoch 694/700
150/150          1s 7ms/step -
loss: 5.3241e-05 - mae: 0.0014 - val_loss: 5.4021e-05 - val_mae: 0.0013
Epoch 695/700
150/150          1s 6ms/step -
loss: 5.8158e-05 - mae: 0.0021 - val_loss: 1.4220e-04 - val_mae: 0.0095
Epoch 696/700
150/150          1s 6ms/step -
loss: 6.0264e-05 - mae: 0.0026 - val_loss: 5.3794e-05 - val_mae: 0.0016
Epoch 697/700
150/150          1s 6ms/step -
loss: 5.3360e-05 - mae: 0.0014 - val_loss: 6.6139e-05 - val_mae: 0.0037
Epoch 698/700
150/150          1s 5ms/step -
loss: 7.3193e-05 - mae: 0.0033 - val_loss: 8.3446e-05 - val_mae: 0.0052
Epoch 699/700
150/150          1s 6ms/step -
loss: 5.6000e-05 - mae: 0.0020 - val_loss: 5.2515e-05 - val_mae: 0.0012
Epoch 700/700
150/150          1s 6ms/step -
loss: 7.4719e-05 - mae: 0.0036 - val_loss: 5.3162e-05 - val_mae: 0.0013

```

```

[13]: w_pred_seq = rnn.predict(X_test_seq)
      w_pred = w_pred_seq[:, -1, :]

      w_pred_original = scaler_y.inverse_transform(w_pred)

      y_test_original = scaler_y.inverse_transform(y_test_seq)

      t_test_plot = t_all[len(t_all) - len(w_pred_original):]

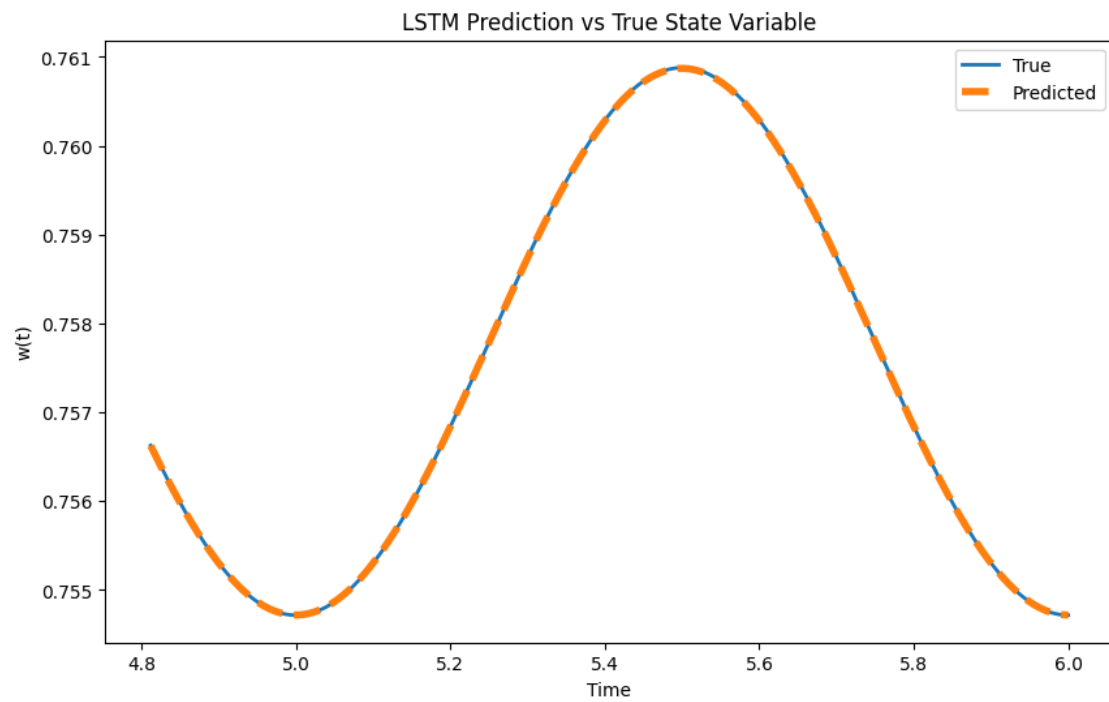
      # ----- Plotting -----
      plt.figure(figsize=(10, 6))
      plt.plot(t_test_plot, y_test_original, label='True', linewidth=2)
      plt.plot(t_test_plot, w_pred_original, label='Predicted', linestyle='--',
               ↪ linewidth=4)
      plt.xlabel('Time')
      plt.ylabel('w(t)')
      plt.title('LSTM Prediction vs True State Variable')
      plt.savefig("testlstm.pdf")
      plt.legend()

```

```
plt.show()
```

38/38

0s 2ms/step



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[ ]:
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[ ]:
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