

Fashion-mnist CNN with autoencoders

In []:

```
from keras.layers import Dense, Input, Conv2D, LSTM, MaxPool2D, UpSampling2D
from sklearn.model_selection import train_test_split
from keras.callbacks import EarlyStopping
from tensorflow.keras.utils import to_categorical
```

In []:

```
from numpy import argmax, array_equal
import matplotlib.pyplot as plt
```

In []:

```
from keras.models import Model
from imgaug import augmenters
from random import randint
```

In []:

```
import pandas as pd
import numpy as np
```

Loading dataset

In []:

```
train = pd.read_csv("/content/sample_data/fashion-mnist_test.csv")
train_x = train[list(train.columns)[1:]].values
train_y = train['label'].values
```

Train and validation dataset

In []:

```
train_x = train[list(train.columns)[1:]].values
train_x, val_x = train_test_split(train_x, test_size=0.2)
```

Reshape

In []:

```
train_x = train_x/255
val_x = val_x/255
```

In []:

```
train_x = train_x.reshape(-1, 28, 28, 1)
val_x = val_x.reshape(-1, 28, 28, 1)
```

Introducing noise

In []:

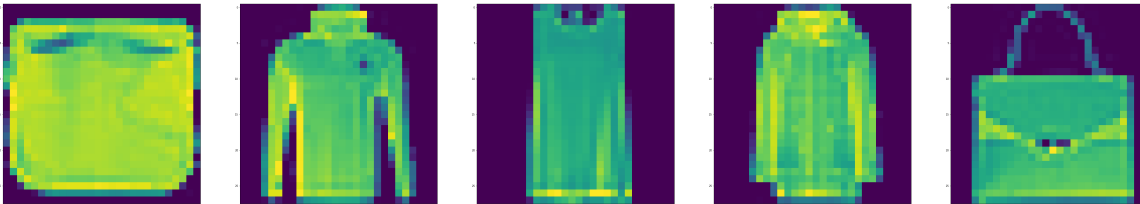
```
noise = augmenters.SaltAndPepper(0.1)
seq_object = augmenters.Sequential([noise])

train_x_n = seq_object.augment_images(train_x * 255) / 255
val_x_n = seq_object.augment_images(val_x * 255) / 255
```

Before adding noise

In []:

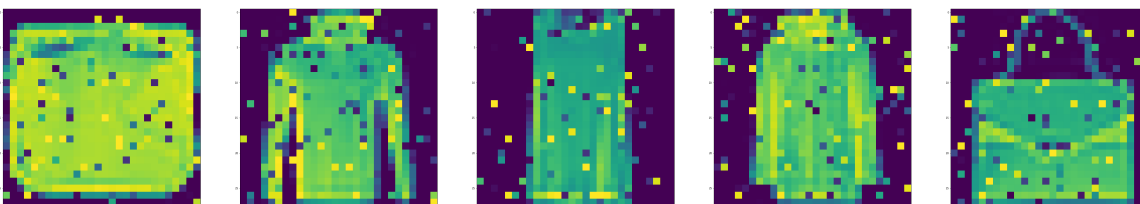
```
f, ax = plt.subplots(1,5)
f.set_size_inches(80, 40)
for i in range(5,10):
    ax[i-5].imshow(train_x[i].reshape(28, 28))
plt.show()
```



Adding adding noise

In []:

```
f, ax = plt.subplots(1,5)
f.set_size_inches(80, 40)
for i in range(5,10):
    ax[i-5].imshow(train_x_n[i].reshape(28, 28))
plt.show()
```



Input Layer

In []:

```
input_layer = Input(shape=(28, 28, 1))
```

Encoding architecture

In []:

```
encoded_layer1 = Conv2D(64, (3, 3), activation='relu', padding='same')(input_layer)
encoded_layer1 = MaxPool2D((2, 2), padding='same')(encoded_layer1)
encoded_layer2 = Conv2D(32, (3, 3), activation='relu', padding='same')(encoded_layer1)
encoded_layer2 = MaxPool2D((2, 2), padding='same')(encoded_layer2)
encoded_layer3 = Conv2D(16, (3, 3), activation='relu', padding='same')(encoded_layer2)
latent_view    = MaxPool2D((2, 2), padding='same')(encoded_layer3)
```

Decoding architecture

In []:

```
decoded_layer1 = Conv2D(16, (3, 3), activation='relu', padding='same')(latent_view)
decoded_layer1 = UpSampling2D((2, 2))(decoded_layer1)
decoded_layer2 = Conv2D(32, (3, 3), activation='relu', padding='same')(decoded_layer1)
decoded_layer2 = UpSampling2D((2, 2))(decoded_layer2)
decoded_layer3 = Conv2D(64, (3, 3), activation='relu')(decoded_layer2)
decoded_layer3 = UpSampling2D((2, 2))(decoded_layer3)
output_layer   = Conv2D(1, (3, 3), padding='same')(decoded_layer3)
```

Compiling model

In []:

```
model = Model(input_layer, output_layer)
model.compile(optimizer='adam', loss='mse')
```

Model summary

In []:

```
model.summary()
```

Model: "model"

Layer (type)	Output Shape	Param #
=====		
input_1 (InputLayer)	[(None, 28, 28, 1)]	0
conv2d (Conv2D)	(None, 28, 28, 64)	640
max_pooling2d (MaxPooling2D)	(None, 14, 14, 64)	0
conv2d_1 (Conv2D)	(None, 14, 14, 32)	18464
max_pooling2d_1 (MaxPooling2D)	(None, 7, 7, 32)	0
conv2d_2 (Conv2D)	(None, 7, 7, 16)	4624
max_pooling2d_2 (MaxPooling2D)	(None, 4, 4, 16)	0
conv2d_3 (Conv2D)	(None, 4, 4, 16)	2320
up_sampling2d (UpSampling2D)	(None, 8, 8, 16)	0
conv2d_4 (Conv2D)	(None, 8, 8, 32)	4640
up_sampling2d_1 (UpSampling2D)	(None, 16, 16, 32)	0
conv2d_5 (Conv2D)	(None, 14, 14, 64)	18496
up_sampling2d_2 (UpSampling2D)	(None, 28, 28, 64)	0
conv2d_6 (Conv2D)	(None, 28, 28, 1)	577
=====		
Total params: 49,761		
Trainable params: 49,761		
Non-trainable params: 0		

Fitting model

In []:

```
early_stopping = EarlyStopping(monitor='val_loss', min_delta=0, patience=10, verbose=5,
mode='auto')
history = model.fit(train_x_n, train_x, epochs=500, batch_size=2048, validation_data=(v
al_x_n, val_x), callbacks=[early_stopping])
```

```
Epoch 1/500
4/4 [=====] - 36s 8s/step - loss: 0.1846 - val_loss: 0.1217
Epoch 2/500
4/4 [=====] - 33s 8s/step - loss: 0.1188 - val_loss: 0.1005
Epoch 3/500
4/4 [=====] - 34s 8s/step - loss: 0.0975 - val_loss: 0.0975
Epoch 4/500
4/4 [=====] - 33s 8s/step - loss: 0.0906 - val_loss: 0.0828
Epoch 5/500
4/4 [=====] - 33s 8s/step - loss: 0.0826 - val_loss: 0.0772
Epoch 6/500
4/4 [=====] - 33s 8s/step - loss: 0.0752 - val_loss: 0.0721
Epoch 7/500
4/4 [=====] - 33s 8s/step - loss: 0.0680 - val_loss: 0.0640
Epoch 8/500
4/4 [=====] - 34s 8s/step - loss: 0.0608 - val_loss: 0.0576
Epoch 9/500
4/4 [=====] - 33s 8s/step - loss: 0.0552 - val_loss: 0.0525
Epoch 10/500
4/4 [=====] - 33s 8s/step - loss: 0.0509 - val_loss: 0.0479
Epoch 11/500
4/4 [=====] - 33s 8s/step - loss: 0.0469 - val_loss: 0.0450
Epoch 12/500
4/4 [=====] - 33s 8s/step - loss: 0.0441 - val_loss: 0.0426
Epoch 13/500
4/4 [=====] - 33s 8s/step - loss: 0.0420 - val_loss: 0.0408
Epoch 14/500
4/4 [=====] - 33s 8s/step - loss: 0.0402 - val_loss: 0.0390
Epoch 15/500
4/4 [=====] - 34s 8s/step - loss: 0.0384 - val_loss: 0.0372
Epoch 16/500
4/4 [=====] - 33s 8s/step - loss: 0.0368 - val_loss: 0.0357
Epoch 17/500
4/4 [=====] - 33s 8s/step - loss: 0.0354 - val_loss: 0.0344
Epoch 18/500
4/4 [=====] - 33s 8s/step - loss: 0.0340 - val_loss: 0.0331
Epoch 19/500
4/4 [=====] - 33s 8s/step - loss: 0.0328 - val_loss: 0.0319
Epoch 20/500
4/4 [=====] - 33s 8s/step - loss: 0.0317 - val_loss: 0.0308
Epoch 21/500
```

```
4/4 [=====] - 34s 8s/step - loss: 0.0307 - val_loss: 0.0299
Epoch 22/500
4/4 [=====] - 33s 8s/step - loss: 0.0298 - val_loss: 0.0291
Epoch 23/500
4/4 [=====] - 33s 8s/step - loss: 0.0291 - val_loss: 0.0284
Epoch 24/500
4/4 [=====] - 33s 8s/step - loss: 0.0284 - val_loss: 0.0279
Epoch 25/500
4/4 [=====] - 33s 8s/step - loss: 0.0280 - val_loss: 0.0272
Epoch 26/500
4/4 [=====] - 33s 8s/step - loss: 0.0274 - val_loss: 0.0269
Epoch 27/500
4/4 [=====] - 33s 8s/step - loss: 0.0270 - val_loss: 0.0267
Epoch 28/500
4/4 [=====] - 33s 8s/step - loss: 0.0267 - val_loss: 0.0261
Epoch 29/500
4/4 [=====] - 33s 8s/step - loss: 0.0263 - val_loss: 0.0257
Epoch 30/500
4/4 [=====] - 33s 8s/step - loss: 0.0260 - val_loss: 0.0254
Epoch 31/500
4/4 [=====] - 33s 8s/step - loss: 0.0256 - val_loss: 0.0253
Epoch 32/500
4/4 [=====] - 33s 8s/step - loss: 0.0254 - val_loss: 0.0248
Epoch 33/500
4/4 [=====] - 33s 8s/step - loss: 0.0251 - val_loss: 0.0247
Epoch 34/500
4/4 [=====] - 33s 8s/step - loss: 0.0249 - val_loss: 0.0244
Epoch 35/500
4/4 [=====] - 39s 10s/step - loss: 0.0246 - val_loss: 0.0242
Epoch 36/500
4/4 [=====] - 34s 8s/step - loss: 0.0244 - val_loss: 0.0239
Epoch 37/500
4/4 [=====] - 34s 9s/step - loss: 0.0240 - val_loss: 0.0236
Epoch 38/500
4/4 [=====] - 33s 8s/step - loss: 0.0238 - val_loss: 0.0236
Epoch 39/500
4/4 [=====] - 33s 8s/step - loss: 0.0248 - val_loss: 0.0255
Epoch 40/500
4/4 [=====] - 34s 8s/step - loss: 0.0246 - val_loss: 0.0232
Epoch 41/500
4/4 [=====] - 33s 8s/step - loss: 0.0238 - val_loss: 0.0238
```

```
ss: 0.0237
Epoch 42/500
4/4 [=====] - 33s 8s/step - loss: 0.0238 - val_lo
ss: 0.0233
Epoch 43/500
4/4 [=====] - 33s 8s/step - loss: 0.0234 - val_lo
ss: 0.0229
Epoch 44/500
4/4 [=====] - 33s 8s/step - loss: 0.0231 - val_lo
ss: 0.0226
Epoch 45/500
4/4 [=====] - 33s 8s/step - loss: 0.0228 - val_lo
ss: 0.0225
Epoch 46/500
4/4 [=====] - 33s 8s/step - loss: 0.0226 - val_lo
ss: 0.0222
Epoch 47/500
4/4 [=====] - 33s 8s/step - loss: 0.0224 - val_lo
ss: 0.0220
Epoch 48/500
4/4 [=====] - 33s 8s/step - loss: 0.0222 - val_lo
ss: 0.0219
Epoch 49/500
4/4 [=====] - 34s 8s/step - loss: 0.0220 - val_lo
ss: 0.0217
Epoch 50/500
4/4 [=====] - 33s 8s/step - loss: 0.0219 - val_lo
ss: 0.0215
Epoch 51/500
4/4 [=====] - 33s 8s/step - loss: 0.0217 - val_lo
ss: 0.0214
Epoch 52/500
4/4 [=====] - 33s 8s/step - loss: 0.0216 - val_lo
ss: 0.0213
Epoch 53/500
4/4 [=====] - 33s 8s/step - loss: 0.0214 - val_lo
ss: 0.0211
Epoch 54/500
4/4 [=====] - 33s 8s/step - loss: 0.0213 - val_lo
ss: 0.0210
Epoch 55/500
4/4 [=====] - 33s 8s/step - loss: 0.0212 - val_lo
ss: 0.0209
Epoch 56/500
4/4 [=====] - 33s 8s/step - loss: 0.0210 - val_lo
ss: 0.0207
Epoch 57/500
4/4 [=====] - 33s 8s/step - loss: 0.0209 - val_lo
ss: 0.0206
Epoch 58/500
4/4 [=====] - 33s 8s/step - loss: 0.0208 - val_lo
ss: 0.0205
Epoch 59/500
4/4 [=====] - 33s 8s/step - loss: 0.0207 - val_lo
ss: 0.0204
Epoch 60/500
4/4 [=====] - 33s 8s/step - loss: 0.0206 - val_lo
ss: 0.0203
Epoch 61/500
4/4 [=====] - 33s 8s/step - loss: 0.0205 - val_lo
ss: 0.0202
```



```
Epoch 62/500
4/4 [=====] - 33s 8s/step - loss: 0.0206 - val_loss: 0.0208
Epoch 63/500
4/4 [=====] - 33s 8s/step - loss: 0.0214 - val_loss: 0.0203
Epoch 64/500
4/4 [=====] - 33s 8s/step - loss: 0.0205 - val_loss: 0.0203
Epoch 65/500
4/4 [=====] - 34s 8s/step - loss: 0.0203 - val_loss: 0.0200
Epoch 66/500
4/4 [=====] - 33s 8s/step - loss: 0.0201 - val_loss: 0.0199
Epoch 67/500
4/4 [=====] - 34s 8s/step - loss: 0.0200 - val_loss: 0.0198
Epoch 68/500
4/4 [=====] - 33s 8s/step - loss: 0.0199 - val_loss: 0.0196
Epoch 69/500
4/4 [=====] - 33s 8s/step - loss: 0.0198 - val_loss: 0.0195
Epoch 70/500
4/4 [=====] - 33s 8s/step - loss: 0.0197 - val_loss: 0.0194
Epoch 71/500
4/4 [=====] - 33s 8s/step - loss: 0.0196 - val_loss: 0.0194
Epoch 72/500
4/4 [=====] - 33s 8s/step - loss: 0.0195 - val_loss: 0.0192
Epoch 73/500
4/4 [=====] - 33s 8s/step - loss: 0.0194 - val_loss: 0.0192
Epoch 74/500
4/4 [=====] - 33s 8s/step - loss: 0.0193 - val_loss: 0.0191
Epoch 75/500
4/4 [=====] - 33s 8s/step - loss: 0.0193 - val_loss: 0.0193
Epoch 76/500
4/4 [=====] - 33s 8s/step - loss: 0.0194 - val_loss: 0.0191
Epoch 77/500
4/4 [=====] - 33s 8s/step - loss: 0.0192 - val_loss: 0.0189
Epoch 78/500
4/4 [=====] - 33s 8s/step - loss: 0.0192 - val_loss: 0.0190
Epoch 79/500
4/4 [=====] - 33s 8s/step - loss: 0.0192 - val_loss: 0.0188
Epoch 80/500
4/4 [=====] - 33s 8s/step - loss: 0.0190 - val_loss: 0.0187
Epoch 81/500
4/4 [=====] - 33s 8s/step - loss: 0.0188 - val_loss: 0.0186
Epoch 82/500
```

```
4/4 [=====] - 33s 8s/step - loss: 0.0189 - val_loss: 0.0188
Epoch 83/500
4/4 [=====] - 33s 8s/step - loss: 0.0192 - val_loss: 0.0193
Epoch 84/500
4/4 [=====] - 33s 8s/step - loss: 0.0192 - val_loss: 0.0184
Epoch 85/500
4/4 [=====] - 33s 8s/step - loss: 0.0187 - val_loss: 0.0186
Epoch 86/500
4/4 [=====] - 33s 8s/step - loss: 0.0186 - val_loss: 0.0185
Epoch 87/500
4/4 [=====] - 33s 8s/step - loss: 0.0187 - val_loss: 0.0183
Epoch 88/500
4/4 [=====] - 33s 8s/step - loss: 0.0185 - val_loss: 0.0184
Epoch 89/500
4/4 [=====] - 33s 8s/step - loss: 0.0185 - val_loss: 0.0181
Epoch 90/500
4/4 [=====] - 33s 8s/step - loss: 0.0183 - val_loss: 0.0182
Epoch 91/500
4/4 [=====] - 33s 8s/step - loss: 0.0183 - val_loss: 0.0181
Epoch 92/500
4/4 [=====] - 35s 9s/step - loss: 0.0182 - val_loss: 0.0180
Epoch 93/500
4/4 [=====] - 34s 8s/step - loss: 0.0183 - val_loss: 0.0181
Epoch 94/500
4/4 [=====] - 34s 9s/step - loss: 0.0182 - val_loss: 0.0180
Epoch 95/500
4/4 [=====] - 34s 9s/step - loss: 0.0182 - val_loss: 0.0180
Epoch 96/500
4/4 [=====] - 34s 9s/step - loss: 0.0181 - val_loss: 0.0181
Epoch 97/500
4/4 [=====] - 34s 9s/step - loss: 0.0183 - val_loss: 0.0182
Epoch 98/500
4/4 [=====] - 34s 9s/step - loss: 0.0183 - val_loss: 0.0179
Epoch 99/500
4/4 [=====] - 34s 9s/step - loss: 0.0179 - val_loss: 0.0176
Epoch 100/500
4/4 [=====] - 34s 9s/step - loss: 0.0178 - val_loss: 0.0176
Epoch 101/500
4/4 [=====] - 34s 9s/step - loss: 0.0177 - val_loss: 0.0175
Epoch 102/500
4/4 [=====] - 34s 9s/step - loss: 0.0177 - val_loss: 0.0177
```

```
ss: 0.0175
Epoch 103/500
4/4 [=====] - 34s 8s/step - loss: 0.0176 - val_lo
ss: 0.0174
Epoch 104/500
4/4 [=====] - 34s 8s/step - loss: 0.0176 - val_lo
ss: 0.0174
Epoch 105/500
4/4 [=====] - 34s 9s/step - loss: 0.0176 - val_lo
ss: 0.0174
Epoch 106/500
4/4 [=====] - 34s 9s/step - loss: 0.0178 - val_lo
ss: 0.0194
Epoch 107/500
4/4 [=====] - 34s 9s/step - loss: 0.0214 - val_lo
ss: 0.0175
Epoch 108/500
4/4 [=====] - 34s 8s/step - loss: 0.0191 - val_lo
ss: 0.0199
Epoch 109/500
4/4 [=====] - 34s 8s/step - loss: 0.0201 - val_lo
ss: 0.0187
Epoch 110/500
4/4 [=====] - 36s 9s/step - loss: 0.0188 - val_lo
ss: 0.0191
Epoch 111/500
4/4 [=====] - 34s 9s/step - loss: 0.0184 - val_lo
ss: 0.0184
Epoch 112/500
4/4 [=====] - 34s 9s/step - loss: 0.0181 - val_lo
ss: 0.0176
Epoch 113/500
4/4 [=====] - 34s 9s/step - loss: 0.0178 - val_lo
ss: 0.0172
Epoch 114/500
4/4 [=====] - 34s 9s/step - loss: 0.0176 - val_lo
ss: 0.0173
Epoch 115/500
4/4 [=====] - 34s 9s/step - loss: 0.0174 - val_lo
ss: 0.0174
Epoch 116/500
4/4 [=====] - 34s 9s/step - loss: 0.0174 - val_lo
ss: 0.0171
Epoch 117/500
4/4 [=====] - 34s 9s/step - loss: 0.0173 - val_lo
ss: 0.0170
Epoch 118/500
4/4 [=====] - 34s 9s/step - loss: 0.0172 - val_lo
ss: 0.0171
Epoch 119/500
4/4 [=====] - 34s 9s/step - loss: 0.0172 - val_lo
ss: 0.0169
Epoch 120/500
4/4 [=====] - 34s 9s/step - loss: 0.0171 - val_lo
ss: 0.0169
Epoch 121/500
4/4 [=====] - 34s 9s/step - loss: 0.0170 - val_lo
ss: 0.0169
Epoch 122/500
4/4 [=====] - 34s 9s/step - loss: 0.0170 - val_lo
ss: 0.0168
```

```
Epoch 123/500
4/4 [=====] - 34s 9s/step - loss: 0.0170 - val_loss: 0.0168
Epoch 124/500
4/4 [=====] - 34s 9s/step - loss: 0.0169 - val_loss: 0.0168
Epoch 125/500
4/4 [=====] - 34s 9s/step - loss: 0.0169 - val_loss: 0.0167
Epoch 126/500
4/4 [=====] - 34s 9s/step - loss: 0.0169 - val_loss: 0.0167
Epoch 127/500
4/4 [=====] - 34s 9s/step - loss: 0.0168 - val_loss: 0.0167
Epoch 128/500
4/4 [=====] - 35s 9s/step - loss: 0.0168 - val_loss: 0.0166
Epoch 129/500
4/4 [=====] - 35s 9s/step - loss: 0.0168 - val_loss: 0.0166
Epoch 130/500
4/4 [=====] - 35s 9s/step - loss: 0.0167 - val_loss: 0.0166
Epoch 131/500
4/4 [=====] - 35s 9s/step - loss: 0.0167 - val_loss: 0.0165
Epoch 132/500
4/4 [=====] - 34s 9s/step - loss: 0.0167 - val_loss: 0.0165
Epoch 133/500
4/4 [=====] - 35s 9s/step - loss: 0.0166 - val_loss: 0.0165
Epoch 134/500
4/4 [=====] - 35s 9s/step - loss: 0.0166 - val_loss: 0.0164
Epoch 135/500
4/4 [=====] - 34s 9s/step - loss: 0.0166 - val_loss: 0.0164
Epoch 136/500
4/4 [=====] - 34s 9s/step - loss: 0.0165 - val_loss: 0.0164
Epoch 137/500
4/4 [=====] - 34s 9s/step - loss: 0.0165 - val_loss: 0.0164
Epoch 138/500
4/4 [=====] - 35s 9s/step - loss: 0.0165 - val_loss: 0.0163
Epoch 139/500
4/4 [=====] - 34s 9s/step - loss: 0.0164 - val_loss: 0.0163
Epoch 140/500
4/4 [=====] - 34s 9s/step - loss: 0.0164 - val_loss: 0.0163
Epoch 141/500
4/4 [=====] - 34s 9s/step - loss: 0.0164 - val_loss: 0.0162
Epoch 142/500
4/4 [=====] - 34s 9s/step - loss: 0.0164 - val_loss: 0.0162
Epoch 143/500
```

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4/4 [=====] - 34s 9s/step - loss: 0.0163 - val_loss: 0.0162
Epoch 144/500
4/4 [=====] - 34s 9s/step - loss: 0.0163 - val_loss: 0.0162
Epoch 145/500
4/4 [=====] - 34s 9s/step - loss: 0.0163 - val_loss: 0.0161
Epoch 146/500
4/4 [=====] - 35s 9s/step - loss: 0.0162 - val_loss: 0.0161
Epoch 147/500
4/4 [=====] - 34s 9s/step - loss: 0.0162 - val_loss: 0.0161
Epoch 148/500
4/4 [=====] - 35s 9s/step - loss: 0.0162 - val_loss: 0.0160
Epoch 149/500
4/4 [=====] - 34s 9s/step - loss: 0.0161 - val_loss: 0.0160
Epoch 150/500
4/4 [=====] - 34s 9s/step - loss: 0.0161 - val_loss: 0.0160
Epoch 151/500
4/4 [=====] - 35s 9s/step - loss: 0.0161 - val_loss: 0.0160
Epoch 152/500
4/4 [=====] - 35s 9s/step - loss: 0.0161 - val_loss: 0.0159
Epoch 153/500
4/4 [=====] - 35s 9s/step - loss: 0.0160 - val_loss: 0.0159
Epoch 154/500
4/4 [=====] - 35s 9s/step - loss: 0.0160 - val_loss: 0.0159
Epoch 155/500
4/4 [=====] - 35s 9s/step - loss: 0.0160 - val_loss: 0.0158
Epoch 156/500
4/4 [=====] - 34s 9s/step - loss: 0.0160 - val_loss: 0.0158
Epoch 157/500
4/4 [=====] - 34s 9s/step - loss: 0.0159 - val_loss: 0.0158
Epoch 158/500
4/4 [=====] - 34s 9s/step - loss: 0.0159 - val_loss: 0.0158
Epoch 159/500
4/4 [=====] - 34s 9s/step - loss: 0.0160 - val_loss: 0.0162
Epoch 160/500
4/4 [=====] - 34s 9s/step - loss: 0.0169 - val_loss: 0.0172
Epoch 161/500
4/4 [=====] - 34s 9s/step - loss: 0.0166 - val_loss: 0.0160
Epoch 162/500
4/4 [=====] - 34s 9s/step - loss: 0.0162 - val_loss: 0.0157
Epoch 163/500
4/4 [=====] - 34s 9s/step - loss: 0.0159 - val_loss: 0.0159
```

```
ss: 0.0157
Epoch 164/500
4/4 [=====] - 34s 9s/step - loss: 0.0159 - val_lo
ss: 0.0157
Epoch 165/500
4/4 [=====] - 34s 9s/step - loss: 0.0158 - val_lo
ss: 0.0157
Epoch 166/500
4/4 [=====] - 34s 9s/step - loss: 0.0157 - val_lo
ss: 0.0156
Epoch 167/500
4/4 [=====] - 34s 9s/step - loss: 0.0157 - val_lo
ss: 0.0156
Epoch 168/500
4/4 [=====] - 34s 9s/step - loss: 0.0157 - val_lo
ss: 0.0155
Epoch 169/500
4/4 [=====] - 34s 9s/step - loss: 0.0156 - val_lo
ss: 0.0155
Epoch 170/500
4/4 [=====] - 34s 9s/step - loss: 0.0156 - val_lo
ss: 0.0155
Epoch 171/500
4/4 [=====] - 34s 9s/step - loss: 0.0156 - val_lo
ss: 0.0155
Epoch 172/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_lo
ss: 0.0154
Epoch 173/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_lo
ss: 0.0155
Epoch 174/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_lo
ss: 0.0154
Epoch 175/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_lo
ss: 0.0154
Epoch 176/500
4/4 [=====] - 36s 9s/step - loss: 0.0154 - val_lo
ss: 0.0153
Epoch 177/500
4/4 [=====] - 34s 9s/step - loss: 0.0154 - val_lo
ss: 0.0153
Epoch 178/500
4/4 [=====] - 34s 9s/step - loss: 0.0154 - val_lo
ss: 0.0156
Epoch 179/500
4/4 [=====] - 35s 9s/step - loss: 0.0167 - val_lo
ss: 0.0180
Epoch 180/500
4/4 [=====] - 35s 9s/step - loss: 0.0170 - val_lo
ss: 0.0162
Epoch 181/500
4/4 [=====] - 34s 9s/step - loss: 0.0161 - val_lo
ss: 0.0158
Epoch 182/500
4/4 [=====] - 34s 9s/step - loss: 0.0157 - val_lo
ss: 0.0159
Epoch 183/500
4/4 [=====] - 34s 9s/step - loss: 0.0157 - val_lo
ss: 0.0156
```

```
Epoch 184/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_loss: 0.0153
Epoch 185/500
4/4 [=====] - 34s 9s/step - loss: 0.0154 - val_loss: 0.0152
Epoch 186/500
4/4 [=====] - 34s 9s/step - loss: 0.0153 - val_loss: 0.0152
Epoch 187/500
4/4 [=====] - 34s 9s/step - loss: 0.0153 - val_loss: 0.0151
Epoch 188/500
4/4 [=====] - 34s 9s/step - loss: 0.0152 - val_loss: 0.0151
Epoch 189/500
4/4 [=====] - 35s 9s/step - loss: 0.0152 - val_loss: 0.0151
Epoch 190/500
4/4 [=====] - 34s 9s/step - loss: 0.0152 - val_loss: 0.0151
Epoch 191/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0150
Epoch 192/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0150
Epoch 193/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0150
Epoch 194/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0150
Epoch 195/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0150
Epoch 196/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0149
Epoch 197/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0149
Epoch 198/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0149
Epoch 199/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0149
Epoch 200/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0149
Epoch 201/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0148
Epoch 202/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0148
Epoch 203/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0149
Epoch 204/500
```

```
4/4 [=====] - 34s 9s/step - loss: 0.0152 - val_loss: 0.0154
Epoch 205/500
4/4 [=====] - 34s 9s/step - loss: 0.0155 - val_loss: 0.0152
Epoch 206/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0150
Epoch 207/500
4/4 [=====] - 34s 9s/step - loss: 0.0151 - val_loss: 0.0148
Epoch 208/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0149
Epoch 209/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0147
Epoch 210/500
4/4 [=====] - 34s 9s/step - loss: 0.0148 - val_loss: 0.0147
Epoch 211/500
4/4 [=====] - 35s 9s/step - loss: 0.0148 - val_loss: 0.0147
Epoch 212/500
4/4 [=====] - 34s 9s/step - loss: 0.0148 - val_loss: 0.0148
Epoch 213/500
4/4 [=====] - 35s 9s/step - loss: 0.0148 - val_loss: 0.0147
Epoch 214/500
4/4 [=====] - 34s 9s/step - loss: 0.0147 - val_loss: 0.0146
Epoch 215/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_loss: 0.0147
Epoch 216/500
4/4 [=====] - 35s 9s/step - loss: 0.0148 - val_loss: 0.0148
Epoch 217/500
4/4 [=====] - 34s 9s/step - loss: 0.0149 - val_loss: 0.0150
Epoch 218/500
4/4 [=====] - 34s 9s/step - loss: 0.0150 - val_loss: 0.0148
Epoch 219/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_loss: 0.0145
Epoch 220/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_loss: 0.0147
Epoch 221/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_loss: 0.0145
Epoch 222/500
4/4 [=====] - 35s 9s/step - loss: 0.0146 - val_loss: 0.0145
Epoch 223/500
4/4 [=====] - 34s 9s/step - loss: 0.0146 - val_loss: 0.0145
Epoch 224/500
4/4 [=====] - 34s 9s/step - loss: 0.0146 - val_loss: 0.0146
```



```
ss: 0.0146
Epoch 225/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_lo
ss: 0.0150
Epoch 226/500
4/4 [=====] - 35s 9s/step - loss: 0.0154 - val_lo
ss: 0.0153
Epoch 227/500
4/4 [=====] - 35s 9s/step - loss: 0.0148 - val_lo
ss: 0.0146
Epoch 228/500
4/4 [=====] - 35s 9s/step - loss: 0.0147 - val_lo
ss: 0.0144
Epoch 229/500
4/4 [=====] - 35s 9s/step - loss: 0.0145 - val_lo
ss: 0.0144
Epoch 230/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0144
Epoch 231/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0144
Epoch 232/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0143
Epoch 233/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0143
Epoch 234/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0143
Epoch 235/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0144
Epoch 236/500
4/4 [=====] - 34s 9s/step - loss: 0.0146 - val_lo
ss: 0.0150
Epoch 237/500
4/4 [=====] - 34s 9s/step - loss: 0.0153 - val_lo
ss: 0.0151
Epoch 238/500
4/4 [=====] - 34s 9s/step - loss: 0.0146 - val_lo
ss: 0.0144
Epoch 239/500
4/4 [=====] - 34s 9s/step - loss: 0.0145 - val_lo
ss: 0.0143
Epoch 240/500
4/4 [=====] - 35s 9s/step - loss: 0.0144 - val_lo
ss: 0.0144
Epoch 241/500
4/4 [=====] - 35s 9s/step - loss: 0.0143 - val_lo
ss: 0.0143
Epoch 242/500
4/4 [=====] - 35s 9s/step - loss: 0.0143 - val_lo
ss: 0.0142
Epoch 243/500
4/4 [=====] - 34s 9s/step - loss: 0.0142 - val_lo
ss: 0.0143
Epoch 244/500
4/4 [=====] - 35s 9s/step - loss: 0.0142 - val_lo
ss: 0.0142
```

```
Epoch 245/500
4/4 [=====] - 34s 9s/step - loss: 0.0142 - val_loss: 0.0142
Epoch 246/500
4/4 [=====] - 35s 9s/step - loss: 0.0142 - val_loss: 0.0142
Epoch 247/500
4/4 [=====] - 34s 9s/step - loss: 0.0142 - val_loss: 0.0141
Epoch 248/500
4/4 [=====] - 34s 9s/step - loss: 0.0141 - val_loss: 0.0141
Epoch 249/500
4/4 [=====] - 34s 9s/step - loss: 0.0141 - val_loss: 0.0142
Epoch 250/500
4/4 [=====] - 35s 9s/step - loss: 0.0143 - val_loss: 0.0148
Epoch 251/500
4/4 [=====] - 35s 9s/step - loss: 0.0154 - val_loss: 0.0151
Epoch 252/500
4/4 [=====] - 35s 9s/step - loss: 0.0145 - val_loss: 0.0147
Epoch 253/500
4/4 [=====] - 34s 9s/step - loss: 0.0145 - val_loss: 0.0142
Epoch 254/500
4/4 [=====] - 34s 9s/step - loss: 0.0144 - val_loss: 0.0141
Epoch 255/500
4/4 [=====] - 34s 9s/step - loss: 0.0142 - val_loss: 0.0140
Epoch 256/500
4/4 [=====] - 34s 9s/step - loss: 0.0141 - val_loss: 0.0141
Epoch 257/500
4/4 [=====] - 34s 9s/step - loss: 0.0141 - val_loss: 0.0141
Epoch 258/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_loss: 0.0140
Epoch 259/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_loss: 0.0140
Epoch 260/500
4/4 [=====] - 35s 9s/step - loss: 0.0140 - val_loss: 0.0140
Epoch 261/500
4/4 [=====] - 35s 9s/step - loss: 0.0140 - val_loss: 0.0139
Epoch 262/500
4/4 [=====] - 35s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 263/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_loss: 0.0139
Epoch 264/500
4/4 [=====] - 35s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 265/500
```

```
4/4 [=====] - 35s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 266/500
4/4 [=====] - 34s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 267/500
4/4 [=====] - 35s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 268/500
4/4 [=====] - 35s 9s/step - loss: 0.0140 - val_loss: 0.0142
Epoch 269/500
4/4 [=====] - 35s 9s/step - loss: 0.0143 - val_loss: 0.0147
Epoch 270/500
4/4 [=====] - 35s 9s/step - loss: 0.0148 - val_loss: 0.0141
Epoch 271/500
4/4 [=====] - 35s 9s/step - loss: 0.0140 - val_loss: 0.0142
Epoch 272/500
4/4 [=====] - 35s 9s/step - loss: 0.0140 - val_loss: 0.0140
Epoch 273/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_loss: 0.0138
Epoch 274/500
4/4 [=====] - 34s 9s/step - loss: 0.0139 - val_loss: 0.0139
Epoch 275/500
4/4 [=====] - 34s 9s/step - loss: 0.0138 - val_loss: 0.0139
Epoch 276/500
4/4 [=====] - 34s 9s/step - loss: 0.0139 - val_loss: 0.0138
Epoch 277/500
4/4 [=====] - 34s 9s/step - loss: 0.0138 - val_loss: 0.0139
Epoch 278/500
4/4 [=====] - 34s 9s/step - loss: 0.0138 - val_loss: 0.0137
Epoch 279/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 280/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 281/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 282/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 283/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 284/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
Epoch 285/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0137
```

```
ss: 0.0138
Epoch 286/500
4/4 [=====] - 34s 9s/step - loss: 0.0138 - val_lo
ss: 0.0139
Epoch 287/500
4/4 [=====] - 34s 9s/step - loss: 0.0139 - val_lo
ss: 0.0139
Epoch 288/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_lo
ss: 0.0139
Epoch 289/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_lo
ss: 0.0136
Epoch 290/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0136
Epoch 291/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0136
Epoch 292/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0137
Epoch 293/500
4/4 [=====] - 35s 9s/step - loss: 0.0137 - val_lo
ss: 0.0137
Epoch 294/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_lo
ss: 0.0137
Epoch 295/500
4/4 [=====] - 35s 9s/step - loss: 0.0137 - val_lo
ss: 0.0137
Epoch 296/500
4/4 [=====] - 35s 9s/step - loss: 0.0137 - val_lo
ss: 0.0138
Epoch 297/500
4/4 [=====] - 35s 9s/step - loss: 0.0138 - val_lo
ss: 0.0138
Epoch 298/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0135
Epoch 299/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_lo
ss: 0.0136
Epoch 300/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0135
Epoch 301/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_lo
ss: 0.0135
Epoch 302/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_lo
ss: 0.0136
Epoch 303/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_lo
ss: 0.0135
Epoch 304/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_lo
ss: 0.0135
Epoch 305/500
4/4 [=====] - 34s 9s/step - loss: 0.0134 - val_lo
ss: 0.0135
```

Epoch 306/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_loss: 0.0138
Epoch 307/500
4/4 [=====] - 34s 9s/step - loss: 0.0144 - val_loss: 0.0153
Epoch 308/500
4/4 [=====] - 34s 9s/step - loss: 0.0147 - val_loss: 0.0135
Epoch 309/500
4/4 [=====] - 34s 9s/step - loss: 0.0140 - val_loss: 0.0135
Epoch 310/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0136
Epoch 311/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_loss: 0.0137
Epoch 312/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_loss: 0.0137
Epoch 313/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_loss: 0.0136
Epoch 314/500
4/4 [=====] - 34s 9s/step - loss: 0.0134 - val_loss: 0.0135
Epoch 315/500
4/4 [=====] - 34s 9s/step - loss: 0.0134 - val_loss: 0.0134
Epoch 316/500
4/4 [=====] - 34s 9s/step - loss: 0.0134 - val_loss: 0.0134
Epoch 317/500
4/4 [=====] - 35s 9s/step - loss: 0.0134 - val_loss: 0.0134
Epoch 318/500
4/4 [=====] - 35s 9s/step - loss: 0.0133 - val_loss: 0.0134
Epoch 319/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 320/500
4/4 [=====] - 35s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 321/500
4/4 [=====] - 35s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 322/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 323/500
4/4 [=====] - 35s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 324/500
4/4 [=====] - 35s 9s/step - loss: 0.0133 - val_loss: 0.0133
Epoch 325/500
4/4 [=====] - 35s 9s/step - loss: 0.0132 - val_loss: 0.0133
Epoch 326/500

```
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0134
Epoch 327/500
4/4 [=====] - 35s 9s/step - loss: 0.0134 - val_loss: 0.0135
Epoch 328/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_loss: 0.0136
Epoch 329/500
4/4 [=====] - 35s 9s/step - loss: 0.0135 - val_loss: 0.0134
Epoch 330/500
4/4 [=====] - 35s 9s/step - loss: 0.0132 - val_loss: 0.0133
Epoch 331/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0133
Epoch 332/500
4/4 [=====] - 35s 9s/step - loss: 0.0132 - val_loss: 0.0132
Epoch 333/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0132
Epoch 334/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0132
Epoch 335/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0132
Epoch 336/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0133
Epoch 337/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0139
Epoch 338/500
4/4 [=====] - 34s 9s/step - loss: 0.0147 - val_loss: 0.0148
Epoch 339/500
4/4 [=====] - 34s 9s/step - loss: 0.0138 - val_loss: 0.0141
Epoch 340/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_loss: 0.0135
Epoch 341/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_loss: 0.0133
Epoch 342/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0132
Epoch 343/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_loss: 0.0132
Epoch 344/500
4/4 [=====] - 34s 9s/step - loss: 0.0132 - val_loss: 0.0131
Epoch 345/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0132
Epoch 346/500
4/4 [=====] - 35s 9s/step - loss: 0.0131 - val_loss: 0.0131
```

```
ss: 0.0132
Epoch 347/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 348/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 349/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 350/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 351/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0131
Epoch 352/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0131
Epoch 353/500
4/4 [=====] - 35s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 354/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0132
Epoch 355/500
4/4 [=====] - 35s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 356/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0131
Epoch 357/500
4/4 [=====] - 35s 9s/step - loss: 0.0131 - val_lo
ss: 0.0131
Epoch 358/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0130
Epoch 359/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0130
Epoch 360/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0130
Epoch 361/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_lo
ss: 0.0130
Epoch 362/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_lo
ss: 0.0130
Epoch 363/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_lo
ss: 0.0130
Epoch 364/500
4/4 [=====] - 35s 9s/step - loss: 0.0130 - val_lo
ss: 0.0133
Epoch 365/500
4/4 [=====] - 34s 9s/step - loss: 0.0135 - val_lo
ss: 0.0141
Epoch 366/500
4/4 [=====] - 34s 9s/step - loss: 0.0137 - val_lo
ss: 0.0130
```

```
Epoch 367/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0133
Epoch 368/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0131
Epoch 369/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0130
Epoch 370/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0130
Epoch 371/500
4/4 [=====] - 34s 9s/step - loss: 0.0129 - val_loss: 0.0129
Epoch 372/500
4/4 [=====] - 34s 9s/step - loss: 0.0129 - val_loss: 0.0130
Epoch 373/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0130
Epoch 374/500
4/4 [=====] - 34s 9s/step - loss: 0.0129 - val_loss: 0.0129
Epoch 375/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 376/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 377/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 378/500
4/4 [=====] - 34s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 379/500
4/4 [=====] - 34s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 380/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0131
Epoch 381/500
4/4 [=====] - 35s 9s/step - loss: 0.0132 - val_loss: 0.0139
Epoch 382/500
4/4 [=====] - 35s 9s/step - loss: 0.0137 - val_loss: 0.0131
Epoch 383/500
4/4 [=====] - 36s 9s/step - loss: 0.0129 - val_loss: 0.0131
Epoch 384/500
4/4 [=====] - 36s 9s/step - loss: 0.0129 - val_loss: 0.0129
Epoch 385/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0130
Epoch 386/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0128
Epoch 387/500
```



```
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0128
Epoch 388/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_loss: 0.0128
Epoch 389/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 390/500
4/4 [=====] - 36s 9s/step - loss: 0.0128 - val_loss: 0.0129
Epoch 391/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0128
Epoch 392/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_loss: 0.0128
Epoch 393/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_loss: 0.0128
Epoch 394/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_loss: 0.0128
Epoch 395/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0130
Epoch 396/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0137
Epoch 397/500
4/4 [=====] - 34s 9s/step - loss: 0.0136 - val_loss: 0.0131
Epoch 398/500
4/4 [=====] - 34s 9s/step - loss: 0.0128 - val_loss: 0.0132
Epoch 399/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0128
Epoch 400/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0129
Epoch 401/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_loss: 0.0129
Epoch 402/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_loss: 0.0127
Epoch 403/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_loss: 0.0128
Epoch 404/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_loss: 0.0127
Epoch 405/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_loss: 0.0127
Epoch 406/500
4/4 [=====] - 35s 9s/step - loss: 0.0126 - val_loss: 0.0127
Epoch 407/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_loss: 0.0126
```

```
ss: 0.0127
Epoch 408/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0127
Epoch 409/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0127
Epoch 410/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_lo
ss: 0.0128
Epoch 411/500
4/4 [=====] - 34s 9s/step - loss: 0.0128 - val_lo
ss: 0.0129
Epoch 412/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_lo
ss: 0.0129
Epoch 413/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_lo
ss: 0.0127
Epoch 414/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0128
Epoch 415/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_lo
ss: 0.0129
Epoch 416/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_lo
ss: 0.0127
Epoch 417/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0127
Epoch 418/500
4/4 [=====] - 35s 9s/step - loss: 0.0126 - val_lo
ss: 0.0127
Epoch 419/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_lo
ss: 0.0128
Epoch 420/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_lo
ss: 0.0128
Epoch 421/500
4/4 [=====] - 35s 9s/step - loss: 0.0126 - val_lo
ss: 0.0127
Epoch 422/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_lo
ss: 0.0126
Epoch 423/500
4/4 [=====] - 34s 9s/step - loss: 0.0125 - val_lo
ss: 0.0127
Epoch 424/500
4/4 [=====] - 35s 9s/step - loss: 0.0126 - val_lo
ss: 0.0128
Epoch 425/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_lo
ss: 0.0127
Epoch 426/500
4/4 [=====] - 35s 9s/step - loss: 0.0126 - val_lo
ss: 0.0126
Epoch 427/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_lo
ss: 0.0126
```

```
Epoch 428/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0126
Epoch 429/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0126
Epoch 430/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0126
Epoch 431/500
4/4 [=====] - 35s 9s/step - loss: 0.0127 - val_loss: 0.0133
Epoch 432/500
4/4 [=====] - 35s 9s/step - loss: 0.0138 - val_loss: 0.0136
Epoch 433/500
4/4 [=====] - 35s 9s/step - loss: 0.0129 - val_loss: 0.0130
Epoch 434/500
4/4 [=====] - 35s 9s/step - loss: 0.0128 - val_loss: 0.0126
Epoch 435/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_loss: 0.0126
Epoch 436/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0126
Epoch 437/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0126
Epoch 438/500
4/4 [=====] - 35s 9s/step - loss: 0.0125 - val_loss: 0.0125
Epoch 439/500
4/4 [=====] - 35s 9s/step - loss: 0.0124 - val_loss: 0.0126
Epoch 440/500
4/4 [=====] - 35s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 441/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 442/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 443/500
4/4 [=====] - 35s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 444/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 445/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 446/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 447/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 448/500
```

```
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 449/500
4/4 [=====] - 35s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 450/500
4/4 [=====] - 35s 9s/step - loss: 0.0124 - val_loss: 0.0127
Epoch 451/500
4/4 [=====] - 34s 9s/step - loss: 0.0128 - val_loss: 0.0132
Epoch 452/500
4/4 [=====] - 34s 9s/step - loss: 0.0131 - val_loss: 0.0128
Epoch 453/500
4/4 [=====] - 34s 9s/step - loss: 0.0125 - val_loss: 0.0127
Epoch 454/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_loss: 0.0125
Epoch 455/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0127
Epoch 456/500
4/4 [=====] - 34s 9s/step - loss: 0.0125 - val_loss: 0.0125
Epoch 457/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 458/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0125
Epoch 459/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 460/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0125
Epoch 461/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 462/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 463/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0125
Epoch 464/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_loss: 0.0125
Epoch 465/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 466/500
4/4 [=====] - 34s 8s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 467/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0124
Epoch 468/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_loss: 0.0123
```

```
ss: 0.0124
Epoch 469/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_lo
ss: 0.0127
Epoch 470/500
4/4 [=====] - 34s 9s/step - loss: 0.0129 - val_lo
ss: 0.0132
Epoch 471/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_lo
ss: 0.0124
Epoch 472/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0126
Epoch 473/500
4/4 [=====] - 34s 8s/step - loss: 0.0123 - val_lo
ss: 0.0124
Epoch 474/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0124
Epoch 475/500
4/4 [=====] - 37s 9s/step - loss: 0.0122 - val_lo
ss: 0.0124
Epoch 476/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 477/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 478/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0124
Epoch 479/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0124
Epoch 480/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 481/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 482/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0126
Epoch 483/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0129
Epoch 484/500
4/4 [=====] - 34s 9s/step - loss: 0.0127 - val_lo
ss: 0.0124
Epoch 485/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 486/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0124
Epoch 487/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 488/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0124
```

```

Epoch 489/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0124
Epoch 490/500
4/4 [=====] - 34s 9s/step - loss: 0.0122 - val_lo
ss: 0.0123
Epoch 491/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0123
Epoch 492/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0123
Epoch 493/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0123
Epoch 494/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0122
Epoch 495/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0123
Epoch 496/500
4/4 [=====] - 34s 9s/step - loss: 0.0121 - val_lo
ss: 0.0124
Epoch 497/500
4/4 [=====] - 34s 9s/step - loss: 0.0126 - val_lo
ss: 0.0133
Epoch 498/500
4/4 [=====] - 34s 9s/step - loss: 0.0133 - val_lo
ss: 0.0127
Epoch 499/500
4/4 [=====] - 34s 9s/step - loss: 0.0123 - val_lo
ss: 0.0129
Epoch 500/500
4/4 [=====] - 34s 9s/step - loss: 0.0124 - val_lo
ss: 0.0123

```

In []:

```

preds = model.predict(val_x_n[:10])
f, ax = plt.subplots(1,5)
f.set_size_inches(80, 40)
for i in range(5,10):
    ax[i-5].imshow(preds[i].reshape(28, 28))
plt.show()

```

