assignment_13

April 19, 2020

1 Assignment

1. change the `encoding_dim` through various values (`range(2,18,2)` and store or keep track of the best loss you can get. Plot the 8 pairs of dimensions vs loss on a scatter plot
2. using the previous assignment's model of detecting images, how does the accuracy change when you run the digit-prediction model on these 'decoded' values?
3. apply noise to only the input of the autoencoder (not the output). demonstrate that your autoencoder can strip out noise.

[128]:
```
import keras
from keras.models import Sequential
from keras.optimizers import RMSprop
from keras.layers import Dense, Dropout, Flatten
from keras.callbacks import TensorBoard
from keras.layers import Input, Dense
from keras.models import Model
from keras.datasets import mnist
from skimage.util import random_noise
from keras import metrics
from sklearn.model_selection import train_test_split
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
%matplotlib inline
```

[67]:
```
# gather data and split into training and testing vars.
(xtrain, ytrain), (xtest, ytest) = mnist.load_data()

xtrain = xtrain.astype('float32') / 255.
xtest = xtest.astype('float32') / 255.
xtrain = xtrain.reshape((len(xtrain), np.prod(xtrain.shape[1:])))
xtest = xtest.reshape((len(xtest), np.prod(xtest.shape[1:])))
xtrain.shape, xtest.shape
ytest.shape
```

[67]:
```
(10000,)
```

2 1. Change the `encoding_dim` through various values (`range(2,18,2)` and store or keep track of the best loss you can get. Plot the 8 pairs of dimensions vs loss on a scatter plot

[17]:
```
loss_score = {}
for iter_dim in range(2,18,2):
    # this is the size of our encoded representations
    encoding_dim = iter_dim  # 32 floats -> compression of factor 24.5,␣
 ↪assuming the input is 784 floats

    # this is our input placeholder
    x = input_img = Input(shape=(784,))
    # "encoded" is the encoded representation of the input
    x = Dense(256, activation='relu')(x)
    x = Dense(128, activation='relu')(x)
    encoded = Dense(encoding_dim, activation='relu')(x)


    # "decoded" is the lossy reconstruction of the input
    x = Dense(128, activation='relu')(encoded)
    x = Dense(256, activation='relu')(x)
    decoded = Dense(784, activation='sigmoid')(x)

    # this model maps an input to its reconstruction
    autoencoder = Model(input_img, decoded)

    encoder = Model(input_img, encoded)

    # create a placeholder for an encoded (32-dimensional) input
    encoded_input = Input(shape=(encoding_dim,))
    # retrieve the last layer of the autoencoder model
    dcd1 = autoencoder.layers[-1]
    dcd2 = autoencoder.layers[-2]
    dcd3 = autoencoder.layers[-3]

    # create the decoder model
    decoder = Model(encoded_input, dcd1(dcd2(dcd3(encoded_input))))

    # compile autoencoder
    autoencoder.compile(optimizer='adadelta', loss='binary_crossentropy')

    autoencoder.fit(xtrain, xtrain,
                epochs=100,
                batch_size=256,
                shuffle=True,
                validation_data=(xtest, xtest))
```

```
    loss_score[iter_dim] = autoencoder.evaluate(xtrain, xtrain, verbose = 0)
```

```
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.3511 -
val_loss: 0.2662
Epoch 2/100
60000/60000 [==============================] - 2s 39us/step - loss: 0.2596 -
val_loss: 0.2561
Epoch 3/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2538 -
val_loss: 0.2528
Epoch 4/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2517 -
val_loss: 0.2520
Epoch 5/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2508 -
val_loss: 0.2511
Epoch 6/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2501 -
val_loss: 0.2503
Epoch 7/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2495 -
val_loss: 0.2505
Epoch 8/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2487 -
val_loss: 0.2489
Epoch 9/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2478 -
val_loss: 0.2473
Epoch 10/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2467 -
val_loss: 0.2462
Epoch 11/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2455 -
val_loss: 0.2448
Epoch 12/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2444 -
val_loss: 0.2437
Epoch 13/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2436 -
val_loss: 0.2433
Epoch 14/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2429 -
val_loss: 0.2428
Epoch 15/100
```

```
60000/60000 [==============================] - 3s 43us/step - loss: 0.2423 -
val_loss: 0.2419
Epoch 16/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2418 -
val_loss: 0.2418
Epoch 17/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2414 -
val_loss: 0.2413
Epoch 18/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2410 -
val_loss: 0.2410
Epoch 19/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2407 -
val_loss: 0.2405
Epoch 20/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2404 -
val_loss: 0.2405
Epoch 21/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2402 -
val_loss: 0.2412
Epoch 22/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2399 -
val_loss: 0.2397
Epoch 23/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2397 -
val_loss: 0.2398
Epoch 24/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2394 -
val_loss: 0.2394
Epoch 25/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2393 -
val_loss: 0.2391
Epoch 26/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2390 -
val_loss: 0.2386
Epoch 27/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2388 -
val_loss: 0.2384
Epoch 28/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2386 -
val_loss: 0.2379
Epoch 29/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2384 -
val_loss: 0.2384
Epoch 30/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2381 -
val_loss: 0.2382
Epoch 31/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.2379 -
val_loss: 0.2377
Epoch 32/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2377 -
val_loss: 0.2376
Epoch 33/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2375 -
val_loss: 0.2371
Epoch 34/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2373 -
val_loss: 0.2370
Epoch 35/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2370 -
val_loss: 0.2365
Epoch 36/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2369 -
val_loss: 0.2363
Epoch 37/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2367 -
val_loss: 0.2372
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2365 -
val_loss: 0.2358
Epoch 39/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2364 -
val_loss: 0.2356
Epoch 40/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2362 -
val_loss: 0.2355
Epoch 41/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2361 -
val_loss: 0.2355
Epoch 42/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2360 -
val_loss: 0.2353
Epoch 43/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2358 -
val_loss: 0.2352
Epoch 44/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2357 -
val_loss: 0.2351
Epoch 45/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2356 -
val_loss: 0.2349
Epoch 46/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2355 -
val_loss: 0.2348
Epoch 47/100
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60000/60000 [==============================] - 3s 45us/step - loss: 0.2353 -
val_loss: 0.2349
Epoch 48/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2352 -
val_loss: 0.2345
Epoch 49/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2351 -
val_loss: 0.2346
Epoch 50/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2349 -
val_loss: 0.2345
Epoch 51/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2347 -
val_loss: 0.2338
Epoch 52/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2343 -
val_loss: 0.2329
Epoch 53/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2303 -
val_loss: 0.2259
Epoch 54/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2254 -
val_loss: 0.2229
Epoch 55/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2231 -
val_loss: 0.2212
Epoch 56/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2215 -
val_loss: 0.2200
Epoch 57/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2204 -
val_loss: 0.2186
Epoch 58/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2193 -
val_loss: 0.2183
Epoch 59/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2183 -
val_loss: 0.2167
Epoch 60/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2171 -
val_loss: 0.2159
Epoch 61/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2159 -
val_loss: 0.2148
Epoch 62/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2147 -
val_loss: 0.2136
Epoch 63/100
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60000/60000 [==============================] - 3s 43us/step - loss: 0.2136 -
val_loss: 0.2126
Epoch 64/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2126 -
val_loss: 0.2120
Epoch 65/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2118 -
val_loss: 0.2113
Epoch 66/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2110 -
val_loss: 0.2104
Epoch 67/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2101 -
val_loss: 0.2101
Epoch 68/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2094 -
val_loss: 0.2090
Epoch 69/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2086 -
val_loss: 0.2086
Epoch 70/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2079 -
val_loss: 0.2076
Epoch 71/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2072 -
val_loss: 0.2073
Epoch 72/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2065 -
val_loss: 0.2065
Epoch 73/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2058 -
val_loss: 0.2063
Epoch 74/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2052 -
val_loss: 0.2054
Epoch 75/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2046 -
val_loss: 0.2050
Epoch 76/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2041 -
val_loss: 0.2045
Epoch 77/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2035 -
val_loss: 0.2041
Epoch 78/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2031 -
val_loss: 0.2032
Epoch 79/100
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60000/60000 [==============================] - 3s 46us/step - loss: 0.2025 -
val_loss: 0.2033
Epoch 80/100
60000/60000 [==============================] - 2s 42us/step - loss: 0.2021 -
val_loss: 0.2027
Epoch 81/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2016 -
val_loss: 0.2029
Epoch 82/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2013 -
val_loss: 0.2019
Epoch 83/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2008 -
val_loss: 0.2013
Epoch 84/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2005 -
val_loss: 0.2006
Epoch 85/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2001 -
val_loss: 0.2008
Epoch 86/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1997 -
val_loss: 0.2006
Epoch 87/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1993 -
val_loss: 0.1999
Epoch 88/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1990 -
val_loss: 0.1995
Epoch 89/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1987 -
val_loss: 0.1991
Epoch 90/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1983 -
val_loss: 0.1992
Epoch 91/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1981 -
val_loss: 0.1988
Epoch 92/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1977 -
val_loss: 0.1983
Epoch 93/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1974 -
val_loss: 0.1978
Epoch 94/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1971 -
val_loss: 0.1977
Epoch 95/100
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60000/60000 [==============================] - 3s 42us/step - loss: 0.1968 -
val_loss: 0.1978
Epoch 96/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1966 -
val_loss: 0.1972
Epoch 97/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1963 -
val_loss: 0.1985
Epoch 98/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1960 -
val_loss: 0.1973
Epoch 99/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1958 -
val_loss: 0.1970
Epoch 100/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1955 -
val_loss: 0.1967
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.3556 -
val_loss: 0.2634
Epoch 2/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2578 -
val_loss: 0.2529
Epoch 3/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2433 -
val_loss: 0.2341
Epoch 4/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2297 -
val_loss: 0.2265
Epoch 5/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2248 -
val_loss: 0.2229
Epoch 6/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2203 -
val_loss: 0.2165
Epoch 7/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2122 -
val_loss: 0.2085
Epoch 8/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2054 -
val_loss: 0.2039
Epoch 9/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2008 -
val_loss: 0.1984
Epoch 10/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1965 -
val_loss: 0.1949
```

```
Epoch 11/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1929 -
val_loss: 0.1911
Epoch 12/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1900 -
val_loss: 0.1887
Epoch 13/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1876 -
val_loss: 0.1865
Epoch 14/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1855 -
val_loss: 0.1843
Epoch 15/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1838 -
val_loss: 0.1830
Epoch 16/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1823 -
val_loss: 0.1819
Epoch 17/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1810 -
val_loss: 0.1805
Epoch 18/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1798 -
val_loss: 0.1795
Epoch 19/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1785 -
val_loss: 0.1783
Epoch 20/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1776 -
val_loss: 0.1771
Epoch 21/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1766 -
val_loss: 0.1755
Epoch 22/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1757 -
val_loss: 0.1753
Epoch 23/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1750 -
val_loss: 0.1745
Epoch 24/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1742 -
val_loss: 0.1745
Epoch 25/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1735 -
val_loss: 0.1730
Epoch 26/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1729 -
val_loss: 0.1737
```

```
Epoch 27/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1723 -
val_loss: 0.1723
Epoch 28/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1717 -
val_loss: 0.1719
Epoch 29/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1712 -
val_loss: 0.1705
Epoch 30/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1706 -
val_loss: 0.1703
Epoch 31/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1699 -
val_loss: 0.1696
Epoch 32/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1696 -
val_loss: 0.1709
Epoch 33/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1690 -
val_loss: 0.1684
Epoch 34/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1685 -
val_loss: 0.1691
Epoch 35/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1681 -
val_loss: 0.1690
Epoch 36/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1677 -
val_loss: 0.1685
Epoch 37/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1673 -
val_loss: 0.1674
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1668 -
val_loss: 0.1669
Epoch 39/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1664 -
val_loss: 0.1671
Epoch 40/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1661 -
val_loss: 0.1657
Epoch 41/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1657 -
val_loss: 0.1660
Epoch 42/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1653 -
val_loss: 0.1691
```

```
Epoch 43/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1650 -
val_loss: 0.1657
Epoch 44/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1646 -
val_loss: 0.1640
Epoch 45/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1642 -
val_loss: 0.1643
Epoch 46/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1639 -
val_loss: 0.1646
Epoch 47/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1637 -
val_loss: 0.1639
Epoch 48/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1633 -
val_loss: 0.1636
Epoch 49/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1630 -
val_loss: 0.1653
Epoch 50/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1628 -
val_loss: 0.1628
Epoch 51/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1624 -
val_loss: 0.1627
Epoch 52/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1621 -
val_loss: 0.1642
Epoch 53/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1620 -
val_loss: 0.1617
Epoch 54/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1617 -
val_loss: 0.1621
Epoch 55/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1614 -
val_loss: 0.1610
Epoch 56/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1611 -
val_loss: 0.1614
Epoch 57/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1608 -
val_loss: 0.1608
Epoch 58/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1606 -
val_loss: 0.1606
```

```
Epoch 59/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1604 -
val_loss: 0.1613
Epoch 60/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1600 -
val_loss: 0.1614
Epoch 61/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1599 -
val_loss: 0.1599
Epoch 62/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1597 -
val_loss: 0.1601
Epoch 63/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1594 -
val_loss: 0.1586
Epoch 64/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1593 -
val_loss: 0.1596
Epoch 65/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1590 -
val_loss: 0.1591
Epoch 66/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1588 -
val_loss: 0.1597
Epoch 67/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1586 -
val_loss: 0.1583
Epoch 68/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1584 -
val_loss: 0.1589
Epoch 69/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1582 -
val_loss: 0.1583
Epoch 70/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1580 -
val_loss: 0.1579
Epoch 71/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1578 -
val_loss: 0.1598
Epoch 72/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1576 -
val_loss: 0.1582
Epoch 73/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1574 -
val_loss: 0.1581
Epoch 74/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1573 -
val_loss: 0.1581
```

```
Epoch 75/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1571 -
val_loss: 0.1573
Epoch 76/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1568 -
val_loss: 0.1569
Epoch 77/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1568 -
val_loss: 0.1569
Epoch 78/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1566 -
val_loss: 0.1574
Epoch 79/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1563 -
val_loss: 0.1574
Epoch 80/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1562 -
val_loss: 0.1570
Epoch 81/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1559 -
val_loss: 0.1573
Epoch 82/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1559 -
val_loss: 0.1559
Epoch 83/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1558 -
val_loss: 0.1562
Epoch 84/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1555 -
val_loss: 0.1555
Epoch 85/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1555 -
val_loss: 0.1563
Epoch 86/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1553 -
val_loss: 0.1562
Epoch 87/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1550 -
val_loss: 0.1551
Epoch 88/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1548 -
val_loss: 0.1569
Epoch 89/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1547 -
val_loss: 0.1552
Epoch 90/100
60000/60000 [==============================] - 2s 42us/step - loss: 0.1546 -
val_loss: 0.1554
```

```
Epoch 91/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1545 -
val_loss: 0.1546
Epoch 92/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1544 -
val_loss: 0.1563
Epoch 93/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1542 -
val_loss: 0.1547
Epoch 94/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1541 -
val_loss: 0.1552
Epoch 95/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1540 -
val_loss: 0.1556
Epoch 96/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1539 -
val_loss: 0.1554
Epoch 97/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1537 -
val_loss: 0.1548
Epoch 98/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1535 -
val_loss: 0.1547
Epoch 99/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1535 -
val_loss: 0.1542
Epoch 100/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1533 -
val_loss: 0.1539
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.3425 -
val_loss: 0.2630
Epoch 2/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2575 -
val_loss: 0.2520
Epoch 3/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2445 -
val_loss: 0.2380
Epoch 4/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.2326 -
val_loss: 0.2263
Epoch 5/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2237 -
val_loss: 0.2180
Epoch 6/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2138 -
```

```
val_loss: 0.2075
Epoch 7/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2040 -
val_loss: 0.1999
Epoch 8/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1957 -
val_loss: 0.1924
Epoch 9/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1904 -
val_loss: 0.1872
Epoch 10/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1866 -
val_loss: 0.1834
Epoch 11/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1833 -
val_loss: 0.1814
Epoch 12/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1805 -
val_loss: 0.1783
Epoch 13/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1780 -
val_loss: 0.1762
Epoch 14/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1761 -
val_loss: 0.1739
Epoch 15/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1743 -
val_loss: 0.1738
Epoch 16/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1726 -
val_loss: 0.1726
Epoch 17/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1712 -
val_loss: 0.1714
Epoch 18/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1697 -
val_loss: 0.1688
Epoch 19/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1685 -
val_loss: 0.1679
Epoch 20/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1674 -
val_loss: 0.1690
Epoch 21/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1663 -
val_loss: 0.1649
Epoch 22/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1653 -
```

```
val_loss: 0.1645
Epoch 23/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1644 -
val_loss: 0.1647
Epoch 24/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1635 -
val_loss: 0.1634
Epoch 25/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1628 -
val_loss: 0.1635
Epoch 26/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1621 -
val_loss: 0.1613
Epoch 27/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1612 -
val_loss: 0.1608
Epoch 28/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1606 -
val_loss: 0.1602
Epoch 29/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1600 -
val_loss: 0.1596
Epoch 30/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1594 -
val_loss: 0.1600
Epoch 31/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1589 -
val_loss: 0.1589
Epoch 32/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1583 -
val_loss: 0.1604
Epoch 33/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1579 -
val_loss: 0.1595
Epoch 34/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1573 -
val_loss: 0.1575
Epoch 35/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1568 -
val_loss: 0.1574
Epoch 36/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1563 -
val_loss: 0.1562
Epoch 37/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1558 -
val_loss: 0.1555
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1554 -
```

```
val_loss: 0.1547
Epoch 39/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1549 -
val_loss: 0.1550
Epoch 40/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1546 -
val_loss: 0.1543
Epoch 41/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1543 -
val_loss: 0.1543
Epoch 42/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1539 -
val_loss: 0.1537
Epoch 43/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1535 -
val_loss: 0.1561
Epoch 44/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1532 -
val_loss: 0.1552
Epoch 45/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1529 -
val_loss: 0.1540
Epoch 46/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1527 -
val_loss: 0.1546
Epoch 47/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1524 -
val_loss: 0.1550
Epoch 48/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1519 -
val_loss: 0.1522
Epoch 49/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1518 -
val_loss: 0.1521
Epoch 50/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1514 -
val_loss: 0.1511
Epoch 51/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1512 -
val_loss: 0.1518
Epoch 52/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1509 -
val_loss: 0.1505
Epoch 53/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1505 -
val_loss: 0.1506
Epoch 54/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1504 -
```

```
val_loss: 0.1503
Epoch 55/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1501 -
val_loss: 0.1498
Epoch 56/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1498 -
val_loss: 0.1511
Epoch 57/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1497 -
val_loss: 0.1498
Epoch 58/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1495 -
val_loss: 0.1504
Epoch 59/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1492 -
val_loss: 0.1490
Epoch 60/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1490 -
val_loss: 0.1500
Epoch 61/100
60000/60000 [==============================] - 3s 42us/step - loss: 0.1489 -
val_loss: 0.1490
Epoch 62/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1487 -
val_loss: 0.1488
Epoch 63/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1484 -
val_loss: 0.1500
Epoch 64/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1483 -
val_loss: 0.1489
Epoch 65/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1481 -
val_loss: 0.1476
Epoch 66/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1478 -
val_loss: 0.1492
Epoch 67/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1477 -
val_loss: 0.1473
Epoch 68/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1476 -
val_loss: 0.1497
Epoch 69/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1473 -
val_loss: 0.1471
Epoch 70/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1471 -
```

```
val_loss: 0.1479
Epoch 71/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1471 -
val_loss: 0.1476
Epoch 72/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1470 -
val_loss: 0.1471
Epoch 73/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1468 -
val_loss: 0.1464
Epoch 74/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1465 -
val_loss: 0.1476
Epoch 75/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1465 -
val_loss: 0.1464
Epoch 76/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1462 -
val_loss: 0.1491
Epoch 77/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1461 -
val_loss: 0.1473
Epoch 78/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1460 -
val_loss: 0.1472
Epoch 79/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1458 -
val_loss: 0.1465
Epoch 80/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1457 -
val_loss: 0.1454
Epoch 81/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1455 -
val_loss: 0.1462
Epoch 82/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1454 -
val_loss: 0.1456
Epoch 83/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1453 -
val_loss: 0.1476
Epoch 84/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1452 -
val_loss: 0.1459
Epoch 85/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1450 -
val_loss: 0.1456
Epoch 86/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1448 -
```

```
val_loss: 0.1459
Epoch 87/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1447 -
val_loss: 0.1453
Epoch 88/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1446 -
val_loss: 0.1457
Epoch 89/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1444 -
val_loss: 0.1453
Epoch 90/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1444 -
val_loss: 0.1450
Epoch 91/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1444 -
val_loss: 0.1449
Epoch 92/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1442 -
val_loss: 0.1447
Epoch 93/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1440 -
val_loss: 0.1454
Epoch 94/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1440 -
val_loss: 0.1448
Epoch 95/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1438 -
val_loss: 0.1452
Epoch 96/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1438 -
val_loss: 0.1445
Epoch 97/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1435 -
val_loss: 0.1438
Epoch 98/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1436 -
val_loss: 0.1437
Epoch 99/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1434 -
val_loss: 0.1436
Epoch 100/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1434 -
val_loss: 0.1439
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.3383 -
val_loss: 0.2621
Epoch 2/100
```

```
60000/60000 [==============================] - 3s 48us/step - loss: 0.2574 -
val_loss: 0.2534
Epoch 3/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.2453 -
val_loss: 0.2321
Epoch 4/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2224 -
val_loss: 0.2152
Epoch 5/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2106 -
val_loss: 0.2034
Epoch 6/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1985 -
val_loss: 0.1919
Epoch 7/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.1885 -
val_loss: 0.1890
Epoch 8/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1822 -
val_loss: 0.1788
Epoch 9/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1772 -
val_loss: 0.1742
Epoch 10/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1726 -
val_loss: 0.1690
Epoch 11/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1686 -
val_loss: 0.1667
Epoch 12/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1654 -
val_loss: 0.1624
Epoch 13/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1627 -
val_loss: 0.1595
Epoch 14/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1605 -
val_loss: 0.1590
Epoch 15/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1584 -
val_loss: 0.1569
Epoch 16/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1566 -
val_loss: 0.1556
Epoch 17/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1551 -
val_loss: 0.1528
Epoch 18/100
```

```
60000/60000 [==============================] - 3s 44us/step - loss: 0.1535 -
val_loss: 0.1518
Epoch 19/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1521 -
val_loss: 0.1498
Epoch 20/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1510 -
val_loss: 0.1492
Epoch 21/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1498 -
val_loss: 0.1486
Epoch 22/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1489 -
val_loss: 0.1479
Epoch 23/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1478 -
val_loss: 0.1457
Epoch 24/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1471 -
val_loss: 0.1455
Epoch 25/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1463 -
val_loss: 0.1453
Epoch 26/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1454 -
val_loss: 0.1448
Epoch 27/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1449 -
val_loss: 0.1440
Epoch 28/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1442 -
val_loss: 0.1434
Epoch 29/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1437 -
val_loss: 0.1432
Epoch 30/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1429 -
val_loss: 0.1420
Epoch 31/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1424 -
val_loss: 0.1416
Epoch 32/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1419 -
val_loss: 0.1415
Epoch 33/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1414 -
val_loss: 0.1404
Epoch 34/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1409 -
val_loss: 0.1408
Epoch 35/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1405 -
val_loss: 0.1394
Epoch 36/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1401 -
val_loss: 0.1392
Epoch 37/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1396 -
val_loss: 0.1391
Epoch 38/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1392 -
val_loss: 0.1393
Epoch 39/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1389 -
val_loss: 0.1378
Epoch 40/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1385 -
val_loss: 0.1374
Epoch 41/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1381 -
val_loss: 0.1376
Epoch 42/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1377 -
val_loss: 0.1365
Epoch 43/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1374 -
val_loss: 0.1365
Epoch 44/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1371 -
val_loss: 0.1365
Epoch 45/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1367 -
val_loss: 0.1355
Epoch 46/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1363 -
val_loss: 0.1353
Epoch 47/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1361 -
val_loss: 0.1349
Epoch 48/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1357 -
val_loss: 0.1359
Epoch 49/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1354 -
val_loss: 0.1349
Epoch 50/100
```

```
60000/60000 [==============================] - 3s 44us/step - loss: 0.1352 -
val_loss: 0.1349
Epoch 51/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1349 -
val_loss: 0.1341
Epoch 52/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1344 -
val_loss: 0.1347
Epoch 53/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1341 -
val_loss: 0.1336
Epoch 54/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1335 -
val_loss: 0.1331
Epoch 55/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1329 -
val_loss: 0.1322
Epoch 56/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1324 -
val_loss: 0.1315
Epoch 57/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1318 -
val_loss: 0.1316
Epoch 58/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1312 -
val_loss: 0.1299
Epoch 59/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1308 -
val_loss: 0.1308
Epoch 60/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1304 -
val_loss: 0.1306
Epoch 61/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1300 -
val_loss: 0.1290
Epoch 62/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1298 -
val_loss: 0.1285
Epoch 63/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1293 -
val_loss: 0.1285
Epoch 64/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1291 -
val_loss: 0.1296
Epoch 65/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1287 -
val_loss: 0.1277
Epoch 66/100
```

```
60000/60000 [==============================] - 3s 44us/step - loss: 0.1284 -
val_loss: 0.1287
Epoch 67/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1282 -
val_loss: 0.1270
Epoch 68/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1279 -
val_loss: 0.1274
Epoch 69/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1277 -
val_loss: 0.1269
Epoch 70/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1273 -
val_loss: 0.1274
Epoch 71/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1272 -
val_loss: 0.1265
Epoch 72/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1269 -
val_loss: 0.1260
Epoch 73/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1266 -
val_loss: 0.1256
Epoch 74/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1264 -
val_loss: 0.1267
Epoch 75/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1262 -
val_loss: 0.1255
Epoch 76/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1260 -
val_loss: 0.1272
Epoch 77/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1259 -
val_loss: 0.1253
Epoch 78/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1256 -
val_loss: 0.1251
Epoch 79/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1253 -
val_loss: 0.1249
Epoch 80/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1254 -
val_loss: 0.1258
Epoch 81/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1251 -
val_loss: 0.1246
Epoch 82/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1248 -
val_loss: 0.1249
Epoch 83/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1247 -
val_loss: 0.1242
Epoch 84/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1245 -
val_loss: 0.1240
Epoch 85/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1244 -
val_loss: 0.1242
Epoch 86/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1242 -
val_loss: 0.1240
Epoch 87/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1241 -
val_loss: 0.1242
Epoch 88/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1239 -
val_loss: 0.1228
Epoch 89/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1236 -
val_loss: 0.1235
Epoch 90/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1236 -
val_loss: 0.1250
Epoch 91/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1234 -
val_loss: 0.1230
Epoch 92/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1232 -
val_loss: 0.1234
Epoch 93/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1231 -
val_loss: 0.1230
Epoch 94/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1230 -
val_loss: 0.1231
Epoch 95/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1228 -
val_loss: 0.1223
Epoch 96/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1228 -
val_loss: 0.1228
Epoch 97/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1226 -
val_loss: 0.1240
Epoch 98/100
```

```
60000/60000 [==============================] - 3s 43us/step - loss: 0.1225 -
val_loss: 0.1222
Epoch 99/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1223 -
val_loss: 0.1221
Epoch 100/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1221 -
val_loss: 0.1221
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.3356 -
val_loss: 0.2628
Epoch 2/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2572 -
val_loss: 0.2516
Epoch 3/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2444 -
val_loss: 0.2381
Epoch 4/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2323 -
val_loss: 0.2211
Epoch 5/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2114 -
val_loss: 0.2018
Epoch 6/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1990 -
val_loss: 0.1953
Epoch 7/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1914 -
val_loss: 0.1849
Epoch 8/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1821 -
val_loss: 0.1766
Epoch 9/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1746 -
val_loss: 0.1711
Epoch 10/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1697 -
val_loss: 0.1673
Epoch 11/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1655 -
val_loss: 0.1617
Epoch 12/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1616 -
val_loss: 0.1596
Epoch 13/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1575 -
val_loss: 0.1530
```

```
Epoch 14/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1546 -
val_loss: 0.1511
Epoch 15/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1520 -
val_loss: 0.1505
Epoch 16/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1500 -
val_loss: 0.1480
Epoch 17/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1484 -
val_loss: 0.1449
Epoch 18/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1466 -
val_loss: 0.1476
Epoch 19/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1453 -
val_loss: 0.1431
Epoch 20/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1441 -
val_loss: 0.1426
Epoch 21/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1428 -
val_loss: 0.1410
Epoch 22/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1418 -
val_loss: 0.1410
Epoch 23/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1407 -
val_loss: 0.1396
Epoch 24/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1397 -
val_loss: 0.1389
Epoch 25/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1388 -
val_loss: 0.1372
Epoch 26/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1382 -
val_loss: 0.1363
Epoch 27/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1372 -
val_loss: 0.1352
Epoch 28/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1366 -
val_loss: 0.1346
Epoch 29/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1359 -
val_loss: 0.1332
```

```
Epoch 30/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1351 -
val_loss: 0.1332
Epoch 31/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1346 -
val_loss: 0.1333
Epoch 32/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1339 -
val_loss: 0.1321
Epoch 33/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1333 -
val_loss: 0.1324
Epoch 34/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1327 -
val_loss: 0.1309
Epoch 35/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1320 -
val_loss: 0.1315
Epoch 36/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1314 -
val_loss: 0.1308
Epoch 37/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1307 -
val_loss: 0.1290
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1299 -
val_loss: 0.1291
Epoch 39/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1293 -
val_loss: 0.1281
Epoch 40/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1286 -
val_loss: 0.1269
Epoch 41/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1280 -
val_loss: 0.1267
Epoch 42/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1273 -
val_loss: 0.1263
Epoch 43/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1270 -
val_loss: 0.1260
Epoch 44/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1265 -
val_loss: 0.1255
Epoch 45/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1260 -
val_loss: 0.1251
```

```
Epoch 46/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1256 -
val_loss: 0.1258
Epoch 47/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1253 -
val_loss: 0.1245
Epoch 48/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1249 -
val_loss: 0.1237
Epoch 49/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1245 -
val_loss: 0.1245
Epoch 50/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1241 -
val_loss: 0.1239
Epoch 51/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1237 -
val_loss: 0.1219
Epoch 52/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1234 -
val_loss: 0.1233
Epoch 53/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1231 -
val_loss: 0.1223
Epoch 54/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1227 -
val_loss: 0.1218
Epoch 55/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1224 -
val_loss: 0.1219
Epoch 56/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1222 -
val_loss: 0.1217
Epoch 57/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1218 -
val_loss: 0.1208
Epoch 58/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1216 -
val_loss: 0.1206
Epoch 59/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1213 -
val_loss: 0.1207
Epoch 60/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1212 -
val_loss: 0.1199
Epoch 61/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1207 -
val_loss: 0.1196
```

```
Epoch 62/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1204 -
val_loss: 0.1205
Epoch 63/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1203 -
val_loss: 0.1196
Epoch 64/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1201 -
val_loss: 0.1195
Epoch 65/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1198 -
val_loss: 0.1196
Epoch 66/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1196 -
val_loss: 0.1187
Epoch 67/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1194 -
val_loss: 0.1189
Epoch 68/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1192 -
val_loss: 0.1188
Epoch 69/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1190 -
val_loss: 0.1184
Epoch 70/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1187 -
val_loss: 0.1185
Epoch 71/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1186 -
val_loss: 0.1182
Epoch 72/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1182 -
val_loss: 0.1175
Epoch 73/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1182 -
val_loss: 0.1176
Epoch 74/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1179 -
val_loss: 0.1170
Epoch 75/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1179 -
val_loss: 0.1175
Epoch 76/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1176 -
val_loss: 0.1165
Epoch 77/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1173 -
val_loss: 0.1167
```

```
Epoch 78/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1173 -
val_loss: 0.1164
Epoch 79/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1171 -
val_loss: 0.1176
Epoch 80/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1169 -
val_loss: 0.1163
Epoch 81/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1168 -
val_loss: 0.1164
Epoch 82/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1166 -
val_loss: 0.1154
Epoch 83/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1164 -
val_loss: 0.1155
Epoch 84/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1162 -
val_loss: 0.1170
Epoch 85/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1162 -
val_loss: 0.1154
Epoch 86/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1159 -
val_loss: 0.1160
Epoch 87/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1158 -
val_loss: 0.1149
Epoch 88/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1157 -
val_loss: 0.1155
Epoch 89/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1154 -
val_loss: 0.1156
Epoch 90/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1154 -
val_loss: 0.1150
Epoch 91/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1152 -
val_loss: 0.1143
Epoch 92/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1151 -
val_loss: 0.1141
Epoch 93/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1149 -
val_loss: 0.1150
```

```
Epoch 94/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1149 -
val_loss: 0.1147
Epoch 95/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1147 -
val_loss: 0.1150
Epoch 96/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1145 -
val_loss: 0.1146
Epoch 97/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1144 -
val_loss: 0.1138
Epoch 98/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1144 -
val_loss: 0.1144
Epoch 99/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1142 -
val_loss: 0.1140
Epoch 100/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1140 -
val_loss: 0.1136
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.3321 -
val_loss: 0.2645
Epoch 2/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.2581 -
val_loss: 0.2520
Epoch 3/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2410 -
val_loss: 0.2295
Epoch 4/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2229 -
val_loss: 0.2141
Epoch 5/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2086 -
val_loss: 0.2024
Epoch 6/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1971 -
val_loss: 0.1909
Epoch 7/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1866 -
val_loss: 0.1816
Epoch 8/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1792 -
val_loss: 0.1781
Epoch 9/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1734 -
```

```
val_loss: 0.1698
Epoch 10/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1688 -
val_loss: 0.1663
Epoch 11/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1644 -
val_loss: 0.1615
Epoch 12/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1606 -
val_loss: 0.1581
Epoch 13/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1571 -
val_loss: 0.1567
Epoch 14/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1537 -
val_loss: 0.1515
Epoch 15/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1506 -
val_loss: 0.1523
Epoch 16/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1484 -
val_loss: 0.1452
Epoch 17/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1463 -
val_loss: 0.1451
Epoch 18/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1447 -
val_loss: 0.1436
Epoch 19/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1431 -
val_loss: 0.1419
Epoch 20/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1419 -
val_loss: 0.1404
Epoch 21/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1406 -
val_loss: 0.1397
Epoch 22/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1394 -
val_loss: 0.1368
Epoch 23/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1383 -
val_loss: 0.1376
Epoch 24/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1370 -
val_loss: 0.1356
Epoch 25/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1358 -
```

```
val_loss: 0.1344
Epoch 26/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1347 -
val_loss: 0.1326
Epoch 27/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1338 -
val_loss: 0.1331
Epoch 28/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1329 -
val_loss: 0.1303
Epoch 29/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1320 -
val_loss: 0.1305
Epoch 30/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1312 -
val_loss: 0.1298
Epoch 31/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1305 -
val_loss: 0.1297
Epoch 32/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1296 -
val_loss: 0.1278
Epoch 33/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1288 -
val_loss: 0.1287
Epoch 34/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1280 -
val_loss: 0.1265
Epoch 35/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1273 -
val_loss: 0.1258
Epoch 36/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1265 -
val_loss: 0.1263
Epoch 37/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1259 -
val_loss: 0.1256
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1253 -
val_loss: 0.1231
Epoch 39/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1245 -
val_loss: 0.1240
Epoch 40/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1240 -
val_loss: 0.1233
Epoch 41/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1236 -
```

```
val_loss: 0.1209
Epoch 42/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1230 -
val_loss: 0.1214
Epoch 43/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1227 -
val_loss: 0.1220
Epoch 44/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1221 -
val_loss: 0.1228
Epoch 45/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1217 -
val_loss: 0.1206
Epoch 46/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1213 -
val_loss: 0.1204
Epoch 47/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1209 -
val_loss: 0.1203
Epoch 48/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1204 -
val_loss: 0.1195
Epoch 49/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1201 -
val_loss: 0.1196
Epoch 50/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1196 -
val_loss: 0.1199
Epoch 51/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1195 -
val_loss: 0.1205
Epoch 52/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1190 -
val_loss: 0.1181
Epoch 53/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1188 -
val_loss: 0.1177
Epoch 54/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1184 -
val_loss: 0.1176
Epoch 55/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1181 -
val_loss: 0.1171
Epoch 56/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1177 -
val_loss: 0.1173
Epoch 57/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1176 -
```

```
val_loss: 0.1173
Epoch 58/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1172 -
val_loss: 0.1160
Epoch 59/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1170 -
val_loss: 0.1165
Epoch 60/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1167 -
val_loss: 0.1164
Epoch 61/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1164 -
val_loss: 0.1156
Epoch 62/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1161 -
val_loss: 0.1151
Epoch 63/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1159 -
val_loss: 0.1152
Epoch 64/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1156 -
val_loss: 0.1142
Epoch 65/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1153 -
val_loss: 0.1161
Epoch 66/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1151 -
val_loss: 0.1141
Epoch 67/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1147 -
val_loss: 0.1154
Epoch 68/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1145 -
val_loss: 0.1137
Epoch 69/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1141 -
val_loss: 0.1139
Epoch 70/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1138 -
val_loss: 0.1131
Epoch 71/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1134 -
val_loss: 0.1129
Epoch 72/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1133 -
val_loss: 0.1136
Epoch 73/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1130 -
```

```
val_loss: 0.1126
Epoch 74/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1127 -
val_loss: 0.1111
Epoch 75/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1123 -
val_loss: 0.1110
Epoch 76/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1121 -
val_loss: 0.1110
Epoch 77/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1119 -
val_loss: 0.1131
Epoch 78/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1116 -
val_loss: 0.1109
Epoch 79/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1114 -
val_loss: 0.1108
Epoch 80/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1112 -
val_loss: 0.1104
Epoch 81/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1110 -
val_loss: 0.1110
Epoch 82/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1108 -
val_loss: 0.1106
Epoch 83/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1105 -
val_loss: 0.1116
Epoch 84/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1103 -
val_loss: 0.1097
Epoch 85/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1102 -
val_loss: 0.1088
Epoch 86/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1100 -
val_loss: 0.1102
Epoch 87/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1097 -
val_loss: 0.1091
Epoch 88/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1097 -
val_loss: 0.1102
Epoch 89/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1093 -
```

```
val_loss: 0.1092
Epoch 90/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1094 -
val_loss: 0.1087
Epoch 91/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1091 -
val_loss: 0.1083
Epoch 92/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1089 -
val_loss: 0.1079
Epoch 93/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1088 -
val_loss: 0.1084
Epoch 94/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1087 -
val_loss: 0.1078
Epoch 95/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1085 -
val_loss: 0.1083
Epoch 96/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1084 -
val_loss: 0.1074
Epoch 97/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1082 -
val_loss: 0.1073
Epoch 98/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1080 -
val_loss: 0.1078
Epoch 99/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1079 -
val_loss: 0.1072
Epoch 100/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1078 -
val_loss: 0.1075
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.3232 -
val_loss: 0.2620
Epoch 2/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2541 -
val_loss: 0.2444
Epoch 3/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.2338 -
val_loss: 0.2235
Epoch 4/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2135 -
val_loss: 0.2025
Epoch 5/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1959 -
val_loss: 0.1888
Epoch 6/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1854 -
val_loss: 0.1790
Epoch 7/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1776 -
val_loss: 0.1720
Epoch 8/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1711 -
val_loss: 0.1668
Epoch 9/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1651 -
val_loss: 0.1609
Epoch 10/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1597 -
val_loss: 0.1578
Epoch 11/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1555 -
val_loss: 0.1523
Epoch 12/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.1524 -
val_loss: 0.1494
Epoch 13/100
60000/60000 [==============================] - 3s 48us/step - loss: 0.1497 -
val_loss: 0.1455
Epoch 14/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1475 -
val_loss: 0.1455
Epoch 15/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1455 -
val_loss: 0.1442
Epoch 16/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1437 -
val_loss: 0.1414
Epoch 17/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1420 -
val_loss: 0.1397
Epoch 18/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1404 -
val_loss: 0.1368
Epoch 19/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1387 -
val_loss: 0.1366
Epoch 20/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1373 -
val_loss: 0.1357
Epoch 21/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1358 -
val_loss: 0.1321
Epoch 22/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1345 -
val_loss: 0.1336
Epoch 23/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1335 -
val_loss: 0.1313
Epoch 24/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1325 -
val_loss: 0.1298
Epoch 25/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1315 -
val_loss: 0.1295
Epoch 26/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1305 -
val_loss: 0.1285
Epoch 27/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1298 -
val_loss: 0.1291
Epoch 28/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1289 -
val_loss: 0.1288
Epoch 29/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1283 -
val_loss: 0.1257
Epoch 30/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1275 -
val_loss: 0.1258
Epoch 31/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1267 -
val_loss: 0.1253
Epoch 32/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1258 -
val_loss: 0.1234
Epoch 33/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1250 -
val_loss: 0.1236
Epoch 34/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1242 -
val_loss: 0.1236
Epoch 35/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1234 -
val_loss: 0.1211
Epoch 36/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1227 -
val_loss: 0.1214
Epoch 37/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1222 -
val_loss: 0.1205
Epoch 38/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1217 -
val_loss: 0.1205
Epoch 39/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1210 -
val_loss: 0.1196
Epoch 40/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1205 -
val_loss: 0.1204
Epoch 41/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1201 -
val_loss: 0.1201
Epoch 42/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1196 -
val_loss: 0.1188
Epoch 43/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1192 -
val_loss: 0.1171
Epoch 44/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1188 -
val_loss: 0.1182
Epoch 45/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1184 -
val_loss: 0.1172
Epoch 46/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1183 -
val_loss: 0.1180
Epoch 47/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1177 -
val_loss: 0.1160
Epoch 48/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1173 -
val_loss: 0.1170
Epoch 49/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1171 -
val_loss: 0.1164
Epoch 50/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1166 -
val_loss: 0.1155
Epoch 51/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1164 -
val_loss: 0.1147
Epoch 52/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1159 -
val_loss: 0.1155
Epoch 53/100
```

```
60000/60000 [==============================] - 3s 44us/step - loss: 0.1156 -
val_loss: 0.1147
Epoch 54/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1153 -
val_loss: 0.1150
Epoch 55/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1151 -
val_loss: 0.1141
Epoch 56/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1149 -
val_loss: 0.1141
Epoch 57/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1145 -
val_loss: 0.1130
Epoch 58/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1143 -
val_loss: 0.1134
Epoch 59/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1139 -
val_loss: 0.1134
Epoch 60/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1138 -
val_loss: 0.1135
Epoch 61/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1135 -
val_loss: 0.1129
Epoch 62/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1132 -
val_loss: 0.1134
Epoch 63/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1131 -
val_loss: 0.1120
Epoch 64/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1127 -
val_loss: 0.1120
Epoch 65/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1126 -
val_loss: 0.1125
Epoch 66/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1123 -
val_loss: 0.1115
Epoch 67/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1120 -
val_loss: 0.1120
Epoch 68/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1120 -
val_loss: 0.1115
Epoch 69/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1116 -
val_loss: 0.1119
Epoch 70/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1115 -
val_loss: 0.1115
Epoch 71/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1114 -
val_loss: 0.1104
Epoch 72/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1111 -
val_loss: 0.1110
Epoch 73/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1109 -
val_loss: 0.1104
Epoch 74/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1107 -
val_loss: 0.1102
Epoch 75/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1105 -
val_loss: 0.1108
Epoch 76/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1103 -
val_loss: 0.1089
Epoch 77/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1101 -
val_loss: 0.1097
Epoch 78/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1100 -
val_loss: 0.1096
Epoch 79/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1098 -
val_loss: 0.1098
Epoch 80/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1097 -
val_loss: 0.1091
Epoch 81/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1095 -
val_loss: 0.1085
Epoch 82/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1093 -
val_loss: 0.1109
Epoch 83/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1091 -
val_loss: 0.1083
Epoch 84/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1090 -
val_loss: 0.1085
Epoch 85/100
```

```
60000/60000 [==============================] - 3s 45us/step - loss: 0.1089 -
val_loss: 0.1093
Epoch 86/100
60000/60000 [==============================] - 3s 43us/step - loss: 0.1088 -
val_loss: 0.1088
Epoch 87/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1086 -
val_loss: 0.1075
Epoch 88/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1084 -
val_loss: 0.1077
Epoch 89/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1083 -
val_loss: 0.1073
Epoch 90/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1081 -
val_loss: 0.1088
Epoch 91/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1080 -
val_loss: 0.1072
Epoch 92/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1079 -
val_loss: 0.1072
Epoch 93/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1078 -
val_loss: 0.1078
Epoch 94/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1076 -
val_loss: 0.1065
Epoch 95/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1075 -
val_loss: 0.1072
Epoch 96/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1074 -
val_loss: 0.1075
Epoch 97/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1072 -
val_loss: 0.1073
Epoch 98/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1071 -
val_loss: 0.1069
Epoch 99/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1070 -
val_loss: 0.1061
Epoch 100/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1068 -
val_loss: 0.1072
Train on 60000 samples, validate on 10000 samples
```

```
Epoch 1/100
60000/60000 [==============================] - 3s 50us/step - loss: 0.3340 -
val_loss: 0.2628
Epoch 2/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2547 -
val_loss: 0.2434
Epoch 3/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.2315 -
val_loss: 0.2223
Epoch 4/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.2161 -
val_loss: 0.2102
Epoch 5/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.2055 -
val_loss: 0.2003
Epoch 6/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1936 -
val_loss: 0.1873
Epoch 7/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1843 -
val_loss: 0.1790
Epoch 8/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1768 -
val_loss: 0.1738
Epoch 9/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1708 -
val_loss: 0.1666
Epoch 10/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1655 -
val_loss: 0.1621
Epoch 11/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1608 -
val_loss: 0.1589
Epoch 12/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1566 -
val_loss: 0.1529
Epoch 13/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1533 -
val_loss: 0.1504
Epoch 14/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1501 -
val_loss: 0.1460
Epoch 15/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1472 -
val_loss: 0.1469
Epoch 16/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1450 -
val_loss: 0.1420
```

```
Epoch 17/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1431 -
val_loss: 0.1412
Epoch 18/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1412 -
val_loss: 0.1402
Epoch 19/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1395 -
val_loss: 0.1385
Epoch 20/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1379 -
val_loss: 0.1358
Epoch 21/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1363 -
val_loss: 0.1332
Epoch 22/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1347 -
val_loss: 0.1322
Epoch 23/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1333 -
val_loss: 0.1323
Epoch 24/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1321 -
val_loss: 0.1297
Epoch 25/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1309 -
val_loss: 0.1301
Epoch 26/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1300 -
val_loss: 0.1283
Epoch 27/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1289 -
val_loss: 0.1261
Epoch 28/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1281 -
val_loss: 0.1261
Epoch 29/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1273 -
val_loss: 0.1263
Epoch 30/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1265 -
val_loss: 0.1252
Epoch 31/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1257 -
val_loss: 0.1251
Epoch 32/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1251 -
val_loss: 0.1241
```

```
Epoch 33/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1244 -
val_loss: 0.1258
Epoch 34/100
60000/60000 [==============================] - 3s 47us/step - loss: 0.1237 -
val_loss: 0.1229
Epoch 35/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1232 -
val_loss: 0.1218
Epoch 36/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1226 -
val_loss: 0.1202
Epoch 37/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1220 -
val_loss: 0.1199
Epoch 38/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1216 -
val_loss: 0.1199
Epoch 39/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1210 -
val_loss: 0.1202
Epoch 40/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1207 -
val_loss: 0.1195
Epoch 41/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1201 -
val_loss: 0.1215
Epoch 42/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1197 -
val_loss: 0.1186
Epoch 43/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1193 -
val_loss: 0.1181
Epoch 44/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1189 -
val_loss: 0.1178
Epoch 45/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1184 -
val_loss: 0.1175
Epoch 46/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1181 -
val_loss: 0.1158
Epoch 47/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1177 -
val_loss: 0.1171
Epoch 48/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1173 -
val_loss: 0.1161
```

```
Epoch 49/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1169 -
val_loss: 0.1161
Epoch 50/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1166 -
val_loss: 0.1147
Epoch 51/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1162 -
val_loss: 0.1146
Epoch 52/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1160 -
val_loss: 0.1153
Epoch 53/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1156 -
val_loss: 0.1143
Epoch 54/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1153 -
val_loss: 0.1150
Epoch 55/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1150 -
val_loss: 0.1141
Epoch 56/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1146 -
val_loss: 0.1130
Epoch 57/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1145 -
val_loss: 0.1145
Epoch 58/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1140 -
val_loss: 0.1130
Epoch 59/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1137 -
val_loss: 0.1126
Epoch 60/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1133 -
val_loss: 0.1130
Epoch 61/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1131 -
val_loss: 0.1128
Epoch 62/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1127 -
val_loss: 0.1137
Epoch 63/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1125 -
val_loss: 0.1111
Epoch 64/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1120 -
val_loss: 0.1123
```

```
Epoch 65/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1117 -
val_loss: 0.1109
Epoch 66/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1116 -
val_loss: 0.1098
Epoch 67/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1112 -
val_loss: 0.1100
Epoch 68/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1109 -
val_loss: 0.1102
Epoch 69/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1108 -
val_loss: 0.1101
Epoch 70/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1104 -
val_loss: 0.1089
Epoch 71/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1102 -
val_loss: 0.1093
Epoch 72/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1100 -
val_loss: 0.1095
Epoch 73/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1097 -
val_loss: 0.1096
Epoch 74/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1094 -
val_loss: 0.1085
Epoch 75/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1094 -
val_loss: 0.1088
Epoch 76/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1092 -
val_loss: 0.1095
Epoch 77/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1088 -
val_loss: 0.1091
Epoch 78/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1088 -
val_loss: 0.1084
Epoch 79/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1085 -
val_loss: 0.1082
Epoch 80/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1083 -
val_loss: 0.1077
```

```
Epoch 81/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1082 -
val_loss: 0.1071
Epoch 82/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1080 -
val_loss: 0.1074
Epoch 83/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1077 -
val_loss: 0.1069
Epoch 84/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1077 -
val_loss: 0.1070
Epoch 85/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1074 -
val_loss: 0.1068
Epoch 86/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1072 -
val_loss: 0.1072
Epoch 87/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1071 -
val_loss: 0.1069
Epoch 88/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1069 -
val_loss: 0.1065
Epoch 89/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1067 -
val_loss: 0.1057
Epoch 90/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1066 -
val_loss: 0.1064
Epoch 91/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1065 -
val_loss: 0.1058
Epoch 92/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1064 -
val_loss: 0.1052
Epoch 93/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1062 -
val_loss: 0.1062
Epoch 94/100
60000/60000 [==============================] - 3s 46us/step - loss: 0.1061 -
val_loss: 0.1068
Epoch 95/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1059 -
val_loss: 0.1048
Epoch 96/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1058 -
val_loss: 0.1050
```

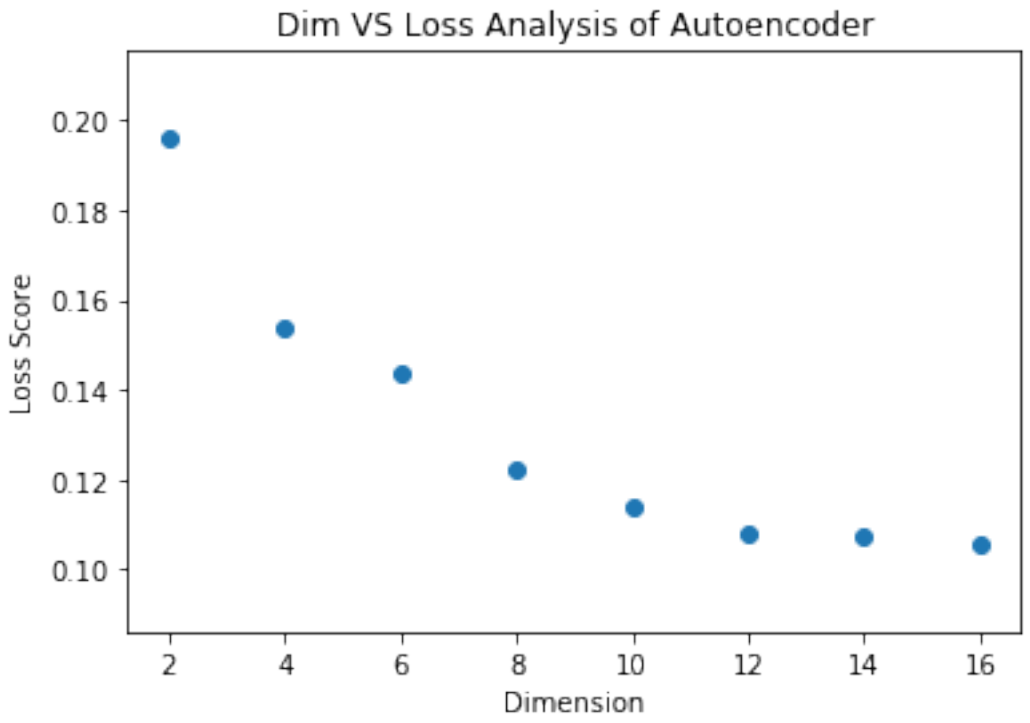
```
Epoch 97/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1056 -
val_loss: 0.1053
Epoch 98/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1057 -
val_loss: 0.1050
Epoch 99/100
60000/60000 [==============================] - 3s 45us/step - loss: 0.1055 -
val_loss: 0.1043
Epoch 100/100
60000/60000 [==============================] - 3s 44us/step - loss: 0.1053 -
val_loss: 0.1052
```

[38]:
```
# Inspect loss scores.
loss_score
```

[38]:
```
{2: 0.19573124536673228,
 4: 0.15351997696956,
 6: 0.14371606947580973,
 8: 0.12235987691084543,
 10: 0.11384244225819906,
 12: 0.10793483013709386,
 14: 0.10745247059265772,
 16: 0.1057592625617981}
```

[39]:
```
plt.scatter(loss_score.keys(), loss_score.values())
plt.title("Dim VS Loss Analysis of Autoencoder")
plt.xlabel("Dimension")
plt.ylabel("Loss Score")
```

[39]:
```
Text(0, 0.5, 'Loss Score')
```



3 2. using the previous assignment's model of detecting images, how does the accuracy change when you run the digit-prediction model on these 'decoded' values?

[95]:
```
# encode and decode testing data.
encoded_imgs = encoder.predict(xtest)
decoded_imgs = decoder.predict(encoded_imgs)
train = np.random.shuffle(decoded_imgs)
train,test = decoded_imgs[:1000,:],decoded_imgs[1000:,:]
print(train.shape, test.shape)
print(decoded_imgs)
#x_train.shape
```

```
(1000, 784) (9000, 784)
[[0.0000000e+00 2.0861626e-07 0.0000000e+00 … 0.0000000e+00
  0.0000000e+00 1.0132790e-06]
 [3.2395124e-05 4.0060282e-04 3.4272671e-06 … 4.6432018e-05
  5.1558018e-06 1.6570091e-05]
 [0.0000000e+00 8.3446503e-07 0.0000000e+00 … 1.4901161e-07
  1.1920929e-07 2.3841858e-07]
 …
 [8.9406967e-08 0.0000000e+00 0.0000000e+00 … 2.0861626e-06
```

```
 0.0000000e+00 0.0000000e+00]
[2.3841858e-07 4.7683716e-07 3.8444996e-06 … 0.0000000e+00
 4.4703484e-07 0.0000000e+00]
[1.7881393e-07 1.1920929e-07 1.1920929e-07 … 0.0000000e+00
 2.6643276e-05 1.1026859e-06]]
```

[109]:
```
x_train,x_test = train_test_split(decoded_imgs)
x_train.shape,x_test.shape
```

[109]:
```
((7500, 784), (2500, 784))
```

[112]:
```
# the data, shuffled and split between train and test sets

x_train = x_train.reshape(7500, 784)
x_test = x_test.reshape(2500, 784)
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
x_test.shape, x_train.shape
```

[112]:
```
((2500, 784), (7500, 784))
```

[149]:
```
initial_mlnn_loss = []


model = Sequential()
model.add(Dense(784, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(10, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(784, activation='softmax'))

model.summary()

model.compile(loss='categorical_crossentropy',
              optimizer=RMSprop(),
              metrics=['accuracy'])

history = model.fit(x_train, x_train,
                    batch_size=10,
                    epochs=20,
                    verbose=1,
                    validation_data=(x_test, x_test))

score = model.evaluate(x_test, x_test, verbose=0)
initial_mlnn_loss.append(model.evaluate(x_test, x_test, verbose=0))
```

```
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Model: "sequential_58"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_249 (Dense)            (None, 784)               615440
_________________________________________________________________
dropout_98 (Dropout)         (None, 784)               0
_________________________________________________________________
dense_250 (Dense)            (None, 10)                7850
_________________________________________________________________
dropout_99 (Dropout)         (None, 10)                0
_________________________________________________________________
dense_251 (Dense)            (None, 784)               8624
=================================================================
Total params: 631,914
Trainable params: 631,914
Non-trainable params: 0
_________________________________________________________________
Train on 7500 samples, validate on 2500 samples
Epoch 1/20
7500/7500 [==============================] - 4s 471us/step - loss: 0.0093 -
accuracy: 0.0139 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 2/20
7500/7500 [==============================] - 3s 340us/step - loss: 0.0092 -
accuracy: 0.0111 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 3/20
7500/7500 [==============================] - 3s 336us/step - loss: 0.0092 -
accuracy: 0.0095 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 4/20
7500/7500 [==============================] - 2s 333us/step - loss: 0.0092 -
accuracy: 0.0089 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 5/20
7500/7500 [==============================] - 3s 335us/step - loss: 0.0092 -
accuracy: 0.0079 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 6/20
7500/7500 [==============================] - 3s 351us/step - loss: 0.0092 -
accuracy: 0.0076 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 7/20
7500/7500 [==============================] - 2s 333us/step - loss: 0.0092 -
accuracy: 0.0089 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 8/20
7500/7500 [==============================] - 3s 333us/step - loss: 0.0092 -
accuracy: 0.0081 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 9/20
```

```
7500/7500 [==============================] - 2s 332us/step - loss: 0.0092 -
accuracy: 0.0073 - val_loss: 0.0092 - val_accuracy: 0.0096
Epoch 10/20
7500/7500 [==============================] - 2s 333us/step - loss: 0.0092 -
accuracy: 0.0076 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 11/20
7500/7500 [==============================] - 3s 334us/step - loss: 0.0092 -
accuracy: 0.0079 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 12/20
7500/7500 [==============================] - 3s 338us/step - loss: 0.0092 -
accuracy: 0.0072 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 13/20
7500/7500 [==============================] - 3s 335us/step - loss: 0.0092 -
accuracy: 0.0085 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 14/20
7500/7500 [==============================] - 3s 336us/step - loss: 0.0092 -
accuracy: 0.0077 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 15/20
7500/7500 [==============================] - 3s 334us/step - loss: 0.0092 -
accuracy: 0.0085 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 16/20
7500/7500 [==============================] - 3s 335us/step - loss: 0.0092 -
accuracy: 0.0079 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 17/20
7500/7500 [==============================] - 3s 336us/step - loss: 0.0092 -
accuracy: 0.0077 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 18/20
7500/7500 [==============================] - 3s 342us/step - loss: 0.0092 -
accuracy: 0.0075 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 19/20
7500/7500 [==============================] - 3s 345us/step - loss: 0.0092 -
accuracy: 0.0077 - val_loss: 0.0092 - val_accuracy: 0.0084
Epoch 20/20
7500/7500 [==============================] - 3s 370us/step - loss: 0.0092 -
accuracy: 0.0071 - val_loss: 0.0092 - val_accuracy: 0.0084
Test loss: 0.00915612373650074
Test accuracy: 0.00839999970048666
```

4 3. apply noise to only the input of the autoencoder (not the output). demonstrate that your autoencoder can strip out noise.

[ ]:
```
# gather data and split into training and testing vars.
(xtrain, ytrain), (xtest, ytest) = mnist.load_data()

xtrain = xtrain.astype('float32') / 255.
```

```
xtest = xtest.astype('float32') / 255.
xtrain = xtrain.reshape((len(xtrain), np.prod(xtrain.shape[1:])))
xtest = xtest.reshape((len(xtest), np.prod(xtest.shape[1:])))
xtrain.shape, xtest.shape
ytest.shape
```

[129]:
```
loss_score_noise = {}
for iter_dim in range(2,18,2):
    # this is the size of our encoded representations
    encoding_dim = iter_dim  # 32 floats -> compression of factor 24.5,␣
 ↪assuming the input is 784 floats

    # this is our input placeholder
    x = input_img = Input(shape=(784,))
    # "encoded" is the encoded representation of the input
    x = Dense(256, activation='relu')(x)
    x = Dense(128, activation='relu')(x)
    encoded = Dense(encoding_dim, activation='relu')(x)


    # "decoded" is the lossy reconstruction of the input
    x = Dense(128, activation='relu')(encoded)
    x = Dense(256, activation='relu')(x)
    decoded = Dense(784, activation='sigmoid')(x)

    # this model maps an input to its reconstruction
    autoencoder = Model(input_img, decoded)

    encoder = Model(input_img, encoded)

    # create a placeholder for an encoded (32-dimensional) input
    encoded_input = Input(shape=(encoding_dim,))
    # retrieve the last layer of the autoencoder model
    dcd1 = autoencoder.layers[-1]
    dcd2 = autoencoder.layers[-2]
    dcd3 = autoencoder.layers[-3]

    # create the decoder model
    decoder = Model(encoded_input, dcd1(dcd2(dcd3(encoded_input))))

    # compile autoencoder
    autoencoder.compile(optimizer='adadelta', loss='binary_crossentropy')

    autoencoder.fit(random_noise(xtrain), xtrain,
                epochs=100,
                batch_size=256,
                shuffle=True,
```

```
                validation_data=(random_noise(xtest), xtest))

    loss_score_noise[iter_dim] = autoencoder.evaluate(xtrain, xtrain, verbose =␣
↪0)
```

```
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 9s 153us/step - loss: 0.4503 -
val_loss: 0.2654
Epoch 2/100
60000/60000 [==============================] - 4s 58us/step - loss: 0.2611 -
val_loss: 0.2576
Epoch 3/100
60000/60000 [==============================] - 4s 60us/step - loss: 0.2553 -
val_loss: 0.2536
Epoch 4/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2524 -
val_loss: 0.2518
Epoch 5/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2511 -
val_loss: 0.2511
Epoch 6/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2501 -
val_loss: 0.2509
Epoch 7/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2490 -
val_loss: 0.2496
Epoch 8/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2476 -
val_loss: 0.2472
Epoch 9/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2460 -
val_loss: 0.2451
Epoch 10/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2447 -
val_loss: 0.2448
Epoch 11/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2439 -
val_loss: 0.2435
Epoch 12/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2431 -
val_loss: 0.2427
Epoch 13/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2425 -
val_loss: 0.2418
Epoch 14/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2419 -
```

```
val_loss: 0.2422
Epoch 15/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2415 -
val_loss: 0.2416
Epoch 16/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2410 -
val_loss: 0.2410
Epoch 17/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.2406 -
val_loss: 0.2412
Epoch 18/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2403 -
val_loss: 0.2401
Epoch 19/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2401 -
val_loss: 0.2399
Epoch 20/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2398 -
val_loss: 0.2399
Epoch 21/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2395 -
val_loss: 0.2393
Epoch 22/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2393 -
val_loss: 0.2387
Epoch 23/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2390 -
val_loss: 0.2387
Epoch 24/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.2388 -
val_loss: 0.2385
Epoch 25/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2385 -
val_loss: 0.2381
Epoch 26/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2383 -
val_loss: 0.2375
Epoch 27/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2380 -
val_loss: 0.2374
Epoch 28/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2378 -
val_loss: 0.2376
Epoch 29/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2376 -
val_loss: 0.2370
Epoch 30/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2373 -
```

```
val_loss: 0.2368
Epoch 31/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2371 -
val_loss: 0.2366
Epoch 32/100
60000/60000 [==============================] - 4s 60us/step - loss: 0.2369 -
val_loss: 0.2363
Epoch 33/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2368 -
val_loss: 0.2361
Epoch 34/100
60000/60000 [==============================] - 4s 66us/step - loss: 0.2366 -
val_loss: 0.2364
Epoch 35/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.2364 -
val_loss: 0.2364
Epoch 36/100
60000/60000 [==============================] - 4s 59us/step - loss: 0.2363 -
val_loss: 0.2358
Epoch 37/100
60000/60000 [==============================] - 4s 60us/step - loss: 0.2361 -
val_loss: 0.2356
Epoch 38/100
60000/60000 [==============================] - 3s 57us/step - loss: 0.2360 -
val_loss: 0.2351
Epoch 39/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2359 -
val_loss: 0.2353
Epoch 40/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2357 -
val_loss: 0.2351
Epoch 41/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2356 -
val_loss: 0.2349
Epoch 42/100
60000/60000 [==============================] - 4s 73us/step - loss: 0.2355 -
val_loss: 0.2351
Epoch 43/100
60000/60000 [==============================] - 4s 61us/step - loss: 0.2353 -
val_loss: 0.2346
Epoch 44/100
60000/60000 [==============================] - 4s 63us/step - loss: 0.2352 -
val_loss: 0.2347
Epoch 45/100
60000/60000 [==============================] - 4s 59us/step - loss: 0.2350 -
val_loss: 0.2343
Epoch 46/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2349 -
```

```
val_loss: 0.2340
Epoch 47/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2347 -
val_loss: 0.2340
Epoch 48/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2346 -
val_loss: 0.2337
Epoch 49/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2344 -
val_loss: 0.2335
Epoch 50/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2342 -
val_loss: 0.2335
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2340 -
val_loss: 0.2332
Epoch 52/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2338 -
val_loss: 0.2330
Epoch 53/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2336 -
val_loss: 0.2329
Epoch 54/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2333 -
val_loss: 0.2327
Epoch 55/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2331 -
val_loss: 0.2323
Epoch 56/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2328 -
val_loss: 0.2322
Epoch 57/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2325 -
val_loss: 0.2318
Epoch 58/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2322 -
val_loss: 0.2316
Epoch 59/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2319 -
val_loss: 0.2309
Epoch 60/100
60000/60000 [==============================] - 3s 57us/step - loss: 0.2316 -
val_loss: 0.2308
Epoch 61/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2312 -
val_loss: 0.2308
Epoch 62/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2308 -
```

```
val_loss: 0.2302
Epoch 63/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2300 -
val_loss: 0.2280
Epoch 64/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2258 -
val_loss: 0.2230
Epoch 65/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2224 -
val_loss: 0.2211
Epoch 66/100
60000/60000 [==============================] - 3s 57us/step - loss: 0.2206 -
val_loss: 0.2194
Epoch 67/100
60000/60000 [==============================] - 3s 57us/step - loss: 0.2193 -
val_loss: 0.2179
Epoch 68/100
60000/60000 [==============================] - 3s 57us/step - loss: 0.2180 -
val_loss: 0.2166
Epoch 69/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2167 -
val_loss: 0.2155
Epoch 70/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2155 -
val_loss: 0.2143
Epoch 71/100
60000/60000 [==============================] - 4s 60us/step - loss: 0.2142 -
val_loss: 0.2132
Epoch 72/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2129 -
val_loss: 0.2117
Epoch 73/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2115 -
val_loss: 0.2114
Epoch 74/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2103 -
val_loss: 0.2096
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2093 -
val_loss: 0.2100
Epoch 76/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2085 -
val_loss: 0.2084
Epoch 77/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2077 -
val_loss: 0.2078
Epoch 78/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2070 -
```

```
val_loss: 0.2069
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2064 -
val_loss: 0.2069
Epoch 80/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2059 -
val_loss: 0.2058
Epoch 81/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2053 -
val_loss: 0.2055
Epoch 82/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2048 -
val_loss: 0.2052
Epoch 83/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2044 -
val_loss: 0.2045
Epoch 84/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2039 -
val_loss: 0.2039
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2035 -
val_loss: 0.2044
Epoch 86/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2032 -
val_loss: 0.2045
Epoch 87/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2028 -
val_loss: 0.2035
Epoch 88/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2023 -
val_loss: 0.2029
Epoch 89/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2020 -
val_loss: 0.2025
Epoch 90/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2017 -
val_loss: 0.2028
Epoch 91/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.2013 -
val_loss: 0.2019
Epoch 92/100
60000/60000 [==============================] - 4s 60us/step - loss: 0.2009 -
val_loss: 0.2023
Epoch 93/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2005 -
val_loss: 0.2020
Epoch 94/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.2002 -
```

```
val_loss: 0.2011
Epoch 95/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.1998 -
val_loss: 0.2009
Epoch 96/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.1996 -
val_loss: 0.2011
Epoch 97/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1992 -
val_loss: 0.2002
Epoch 98/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1988 -
val_loss: 0.1992
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1985 -
val_loss: 0.1996
Epoch 100/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1982 -
val_loss: 0.1994
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 5s 80us/step - loss: 0.3697 -
val_loss: 0.2643
Epoch 2/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2603 -
val_loss: 0.2573
Epoch 3/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2530 -
val_loss: 0.2477
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2415 -
val_loss: 0.2337
Epoch 5/100
60000/60000 [==============================] - 5s 75us/step - loss: 0.2286 -
val_loss: 0.2234
Epoch 6/100
60000/60000 [==============================] - 4s 63us/step - loss: 0.2228 -
val_loss: 0.2198
Epoch 7/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2176 -
val_loss: 0.2138
Epoch 8/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2095 -
val_loss: 0.2059
Epoch 9/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2036 -
val_loss: 0.2024
Epoch 10/100
```

```
60000/60000 [==============================] - 3s 55us/step - loss: 0.1996 -
val_loss: 0.1968
Epoch 11/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1962 -
val_loss: 0.1935
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1933 -
val_loss: 0.1918
Epoch 13/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1908 -
val_loss: 0.1891
Epoch 14/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1885 -
val_loss: 0.1869
Epoch 15/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1865 -
val_loss: 0.1872
Epoch 16/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1846 -
val_loss: 0.1843
Epoch 17/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1831 -
val_loss: 0.1820
Epoch 18/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1817 -
val_loss: 0.1818
Epoch 19/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1804 -
val_loss: 0.1793
Epoch 20/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1792 -
val_loss: 0.1791
Epoch 21/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1782 -
val_loss: 0.1774
Epoch 22/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1769 -
val_loss: 0.1767
Epoch 23/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1761 -
val_loss: 0.1754
Epoch 24/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1752 -
val_loss: 0.1744
Epoch 25/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1744 -
val_loss: 0.1748
Epoch 26/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1737 -
val_loss: 0.1734
Epoch 27/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1728 -
val_loss: 0.1729
Epoch 28/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1722 -
val_loss: 0.1734
Epoch 29/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1715 -
val_loss: 0.1710
Epoch 30/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1707 -
val_loss: 0.1703
Epoch 31/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1703 -
val_loss: 0.1696
Epoch 32/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1694 -
val_loss: 0.1697
Epoch 33/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1691 -
val_loss: 0.1682
Epoch 34/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1684 -
val_loss: 0.1688
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1679 -
val_loss: 0.1680
Epoch 36/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1674 -
val_loss: 0.1679
Epoch 37/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1670 -
val_loss: 0.1676
Epoch 38/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1665 -
val_loss: 0.1663
Epoch 39/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1660 -
val_loss: 0.1656
Epoch 40/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1655 -
val_loss: 0.1666
Epoch 41/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1653 -
val_loss: 0.1642
Epoch 42/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1648 -
val_loss: 0.1650
Epoch 43/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1644 -
val_loss: 0.1645
Epoch 44/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1640 -
val_loss: 0.1641
Epoch 45/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1638 -
val_loss: 0.1652
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1634 -
val_loss: 0.1646
Epoch 47/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1630 -
val_loss: 0.1635
Epoch 48/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1628 -
val_loss: 0.1627
Epoch 49/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1623 -
val_loss: 0.1621
Epoch 50/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1621 -
val_loss: 0.1626
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1618 -
val_loss: 0.1617
Epoch 52/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1614 -
val_loss: 0.1614
Epoch 53/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1612 -
val_loss: 0.1612
Epoch 54/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1610 -
val_loss: 0.1608
Epoch 55/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1607 -
val_loss: 0.1609
Epoch 56/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1605 -
val_loss: 0.1611
Epoch 57/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1602 -
val_loss: 0.1610
Epoch 58/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1600 -
val_loss: 0.1604
Epoch 59/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1599 -
val_loss: 0.1604
Epoch 60/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1593 -
val_loss: 0.1596
Epoch 61/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1593 -
val_loss: 0.1598
Epoch 62/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1590 -
val_loss: 0.1599
Epoch 63/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1588 -
val_loss: 0.1590
Epoch 64/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1585 -
val_loss: 0.1588
Epoch 65/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1584 -
val_loss: 0.1595
Epoch 66/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1581 -
val_loss: 0.1604
Epoch 67/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1581 -
val_loss: 0.1586
Epoch 68/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1578 -
val_loss: 0.1579
Epoch 69/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1576 -
val_loss: 0.1585
Epoch 70/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1574 -
val_loss: 0.1577
Epoch 71/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1573 -
val_loss: 0.1581
Epoch 72/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1571 -
val_loss: 0.1573
Epoch 73/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1569 -
val_loss: 0.1588
Epoch 74/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1567 -
val_loss: 0.1576
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1565 -
val_loss: 0.1566
Epoch 76/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1564 -
val_loss: 0.1567
Epoch 77/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1563 -
val_loss: 0.1564
Epoch 78/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1560 -
val_loss: 0.1568
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1558 -
val_loss: 0.1566
Epoch 80/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1557 -
val_loss: 0.1566
Epoch 81/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1556 -
val_loss: 0.1565
Epoch 82/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1555 -
val_loss: 0.1564
Epoch 83/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1553 -
val_loss: 0.1564
Epoch 84/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1552 -
val_loss: 0.1565
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1550 -
val_loss: 0.1557
Epoch 86/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1550 -
val_loss: 0.1562
Epoch 87/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1547 -
val_loss: 0.1552
Epoch 88/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1545 -
val_loss: 0.1551
Epoch 89/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1545 -
val_loss: 0.1570
Epoch 90/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1544 -
val_loss: 0.1561
Epoch 91/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1542 -
val_loss: 0.1549
Epoch 92/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1541 -
val_loss: 0.1564
Epoch 93/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1541 -
val_loss: 0.1545
Epoch 94/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1537 -
val_loss: 0.1546
Epoch 95/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1537 -
val_loss: 0.1551
Epoch 96/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1537 -
val_loss: 0.1549
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1535 -
val_loss: 0.1544
Epoch 98/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1533 -
val_loss: 0.1541
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1532 -
val_loss: 0.1549
Epoch 100/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1532 -
val_loss: 0.1545
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 4s 72us/step - loss: 0.3263 -
val_loss: 0.2651
Epoch 2/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2576 -
val_loss: 0.2510
Epoch 3/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2437 -
val_loss: 0.2396
Epoch 4/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2374 -
val_loss: 0.2344
Epoch 5/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.2289 -
val_loss: 0.2217
```

```
Epoch 6/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2160 -
val_loss: 0.2105
Epoch 7/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.2085 -
val_loss: 0.2063
Epoch 8/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2040 -
val_loss: 0.2008
Epoch 9/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1994 -
val_loss: 0.1967
Epoch 10/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1933 -
val_loss: 0.1888
Epoch 11/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1881 -
val_loss: 0.1842
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1840 -
val_loss: 0.1818
Epoch 13/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1810 -
val_loss: 0.1794
Epoch 14/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1786 -
val_loss: 0.1777
Epoch 15/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1766 -
val_loss: 0.1752
Epoch 16/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1748 -
val_loss: 0.1729
Epoch 17/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1731 -
val_loss: 0.1711
Epoch 18/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1716 -
val_loss: 0.1705
Epoch 19/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1704 -
val_loss: 0.1696
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1689 -
val_loss: 0.1683
Epoch 21/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1676 -
val_loss: 0.1663
```

```
Epoch 22/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1662 -
val_loss: 0.1641
Epoch 23/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1645 -
val_loss: 0.1637
Epoch 24/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1630 -
val_loss: 0.1630
Epoch 25/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1614 -
val_loss: 0.1582
Epoch 26/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1596 -
val_loss: 0.1572
Epoch 27/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1585 -
val_loss: 0.1566
Epoch 28/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1572 -
val_loss: 0.1546
Epoch 29/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1559 -
val_loss: 0.1576
Epoch 30/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1548 -
val_loss: 0.1535
Epoch 31/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1539 -
val_loss: 0.1521
Epoch 32/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1531 -
val_loss: 0.1525
Epoch 33/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1524 -
val_loss: 0.1523
Epoch 34/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1517 -
val_loss: 0.1510
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1511 -
val_loss: 0.1499
Epoch 36/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1505 -
val_loss: 0.1494
Epoch 37/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1500 -
val_loss: 0.1493
```

```
Epoch 38/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1493 -
val_loss: 0.1485
Epoch 39/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1489 -
val_loss: 0.1490
Epoch 40/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1485 -
val_loss: 0.1474
Epoch 41/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1482 -
val_loss: 0.1486
Epoch 42/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1475 -
val_loss: 0.1470
Epoch 43/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1472 -
val_loss: 0.1481
Epoch 44/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1468 -
val_loss: 0.1467
Epoch 45/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1465 -
val_loss: 0.1459
Epoch 46/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1462 -
val_loss: 0.1453
Epoch 47/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1457 -
val_loss: 0.1448
Epoch 48/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1453 -
val_loss: 0.1451
Epoch 49/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1451 -
val_loss: 0.1445
Epoch 50/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1447 -
val_loss: 0.1448
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1445 -
val_loss: 0.1444
Epoch 52/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1441 -
val_loss: 0.1434
Epoch 53/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1439 -
val_loss: 0.1433
```

```
Epoch 54/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1436 -
val_loss: 0.1452
Epoch 55/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1433 -
val_loss: 0.1435
Epoch 56/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1430 -
val_loss: 0.1426
Epoch 57/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1428 -
val_loss: 0.1439
Epoch 58/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1426 -
val_loss: 0.1424
Epoch 59/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1422 -
val_loss: 0.1411
Epoch 60/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1422 -
val_loss: 0.1414
Epoch 61/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1418 -
val_loss: 0.1418
Epoch 62/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1417 -
val_loss: 0.1411
Epoch 63/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.1414 -
val_loss: 0.1421
Epoch 64/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.1412 -
val_loss: 0.1411
Epoch 65/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1411 -
val_loss: 0.1408
Epoch 66/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1408 -
val_loss: 0.1409
Epoch 67/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1406 -
val_loss: 0.1397
Epoch 68/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1404 -
val_loss: 0.1401
Epoch 69/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1402 -
val_loss: 0.1398
```

```
Epoch 70/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1401 -
val_loss: 0.1402
Epoch 71/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1398 -
val_loss: 0.1397
Epoch 72/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1397 -
val_loss: 0.1421
Epoch 73/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1397 -
val_loss: 0.1400
Epoch 74/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1393 -
val_loss: 0.1398
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1391 -
val_loss: 0.1408
Epoch 76/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1391 -
val_loss: 0.1385
Epoch 77/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1389 -
val_loss: 0.1390
Epoch 78/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1387 -
val_loss: 0.1383
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1385 -
val_loss: 0.1382
Epoch 80/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1384 -
val_loss: 0.1393
Epoch 81/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1382 -
val_loss: 0.1385
Epoch 82/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1381 -
val_loss: 0.1378
Epoch 83/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1379 -
val_loss: 0.1390
Epoch 84/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1378 -
val_loss: 0.1383
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1376 -
val_loss: 0.1384
```

```
Epoch 86/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1375 -
val_loss: 0.1376
Epoch 87/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1374 -
val_loss: 0.1370
Epoch 88/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1371 -
val_loss: 0.1368
Epoch 89/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1372 -
val_loss: 0.1367
Epoch 90/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1369 -
val_loss: 0.1374
Epoch 91/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1369 -
val_loss: 0.1374
Epoch 92/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1366 -
val_loss: 0.1367
Epoch 93/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1365 -
val_loss: 0.1372
Epoch 94/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1364 -
val_loss: 0.1362
Epoch 95/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1364 -
val_loss: 0.1356
Epoch 96/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1362 -
val_loss: 0.1367
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1360 -
val_loss: 0.1365
Epoch 98/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1359 -
val_loss: 0.1372
Epoch 99/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1359 -
val_loss: 0.1360
Epoch 100/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1359 -
val_loss: 0.1359
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 4s 75us/step - loss: 0.3605 -
```

```
val_loss: 0.2644
Epoch 2/100
60000/60000 [==============================] - 3s 50us/step - loss: 0.2593 -
val_loss: 0.2538
Epoch 3/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2460 -
val_loss: 0.2398
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2362 -
val_loss: 0.2306
Epoch 5/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2268 -
val_loss: 0.2239
Epoch 6/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2169 -
val_loss: 0.2096
Epoch 7/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2035 -
val_loss: 0.1963
Epoch 8/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1919 -
val_loss: 0.1857
Epoch 9/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1851 -
val_loss: 0.1826
Epoch 10/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1806 -
val_loss: 0.1777
Epoch 11/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1770 -
val_loss: 0.1740
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1736 -
val_loss: 0.1709
Epoch 13/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1706 -
val_loss: 0.1686
Epoch 14/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1682 -
val_loss: 0.1682
Epoch 15/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1658 -
val_loss: 0.1635
Epoch 16/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1634 -
val_loss: 0.1617
Epoch 17/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1608 -
```

```
val_loss: 0.1590
Epoch 18/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1585 -
val_loss: 0.1590
Epoch 19/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1564 -
val_loss: 0.1536
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1548 -
val_loss: 0.1529
Epoch 21/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1534 -
val_loss: 0.1525
Epoch 22/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1519 -
val_loss: 0.1512
Epoch 23/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1508 -
val_loss: 0.1502
Epoch 24/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1499 -
val_loss: 0.1484
Epoch 25/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1489 -
val_loss: 0.1487
Epoch 26/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1481 -
val_loss: 0.1478
Epoch 27/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1472 -
val_loss: 0.1458
Epoch 28/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1466 -
val_loss: 0.1453
Epoch 29/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1458 -
val_loss: 0.1445
Epoch 30/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1452 -
val_loss: 0.1444
Epoch 31/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1446 -
val_loss: 0.1429
Epoch 32/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1441 -
val_loss: 0.1434
Epoch 33/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1434 -
```

```
val_loss: 0.1427
Epoch 34/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1429 -
val_loss: 0.1420
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1425 -
val_loss: 0.1422
Epoch 36/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1419 -
val_loss: 0.1409
Epoch 37/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1414 -
val_loss: 0.1409
Epoch 38/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1410 -
val_loss: 0.1402
Epoch 39/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1407 -
val_loss: 0.1401
Epoch 40/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1403 -
val_loss: 0.1406
Epoch 41/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1398 -
val_loss: 0.1402
Epoch 42/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1395 -
val_loss: 0.1392
Epoch 43/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1391 -
val_loss: 0.1387
Epoch 44/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1388 -
val_loss: 0.1383
Epoch 45/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1385 -
val_loss: 0.1382
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1381 -
val_loss: 0.1371
Epoch 47/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1378 -
val_loss: 0.1367
Epoch 48/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1375 -
val_loss: 0.1402
Epoch 49/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1373 -
```

```
val_loss: 0.1392
Epoch 50/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1370 -
val_loss: 0.1362
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1367 -
val_loss: 0.1359
Epoch 52/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1363 -
val_loss: 0.1359
Epoch 53/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1362 -
val_loss: 0.1370
Epoch 54/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1359 -
val_loss: 0.1345
Epoch 55/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1358 -
val_loss: 0.1360
Epoch 56/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1355 -
val_loss: 0.1350
Epoch 57/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1352 -
val_loss: 0.1353
Epoch 58/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1350 -
val_loss: 0.1341
Epoch 59/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1348 -
val_loss: 0.1355
Epoch 60/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1346 -
val_loss: 0.1345
Epoch 61/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1345 -
val_loss: 0.1340
Epoch 62/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1342 -
val_loss: 0.1360
Epoch 63/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1340 -
val_loss: 0.1336
Epoch 64/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1339 -
val_loss: 0.1342
Epoch 65/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1336 -
```

```
val_loss: 0.1329
Epoch 66/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1333 -
val_loss: 0.1332
Epoch 67/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1334 -
val_loss: 0.1334
Epoch 68/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1331 -
val_loss: 0.1320
Epoch 69/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1328 -
val_loss: 0.1331
Epoch 70/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1328 -
val_loss: 0.1328
Epoch 71/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1326 -
val_loss: 0.1318
Epoch 72/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1324 -
val_loss: 0.1325
Epoch 73/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1324 -
val_loss: 0.1312
Epoch 74/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1321 -
val_loss: 0.1314
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1319 -
val_loss: 0.1320
Epoch 76/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1318 -
val_loss: 0.1320
Epoch 77/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1316 -
val_loss: 0.1318
Epoch 78/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1316 -
val_loss: 0.1327
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1313 -
val_loss: 0.1309
Epoch 80/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1313 -
val_loss: 0.1324
Epoch 81/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1311 -
```

```
val_loss: 0.1317
Epoch 82/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1310 -
val_loss: 0.1306
Epoch 83/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1308 -
val_loss: 0.1317
Epoch 84/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1307 -
val_loss: 0.1303
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1306 -
val_loss: 0.1311
Epoch 86/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1305 -
val_loss: 0.1305
Epoch 87/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1303 -
val_loss: 0.1295
Epoch 88/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1302 -
val_loss: 0.1296
Epoch 89/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1300 -
val_loss: 0.1303
Epoch 90/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1299 -
val_loss: 0.1299
Epoch 91/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1299 -
val_loss: 0.1308
Epoch 92/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1298 -
val_loss: 0.1299
Epoch 93/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1296 -
val_loss: 0.1297
Epoch 94/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1295 -
val_loss: 0.1297
Epoch 95/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.1293 -
val_loss: 0.1304
Epoch 96/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1292 -
val_loss: 0.1297
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1292 -
```

```
val_loss: 0.1299
Epoch 98/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1290 -
val_loss: 0.1303
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1290 -
val_loss: 0.1295
Epoch 100/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1289 -
val_loss: 0.1287
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 4s 74us/step - loss: 0.3491 -
val_loss: 0.2628
Epoch 2/100
60000/60000 [==============================] - 3s 50us/step - loss: 0.2587 -
val_loss: 0.2546
Epoch 3/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2477 -
val_loss: 0.2413
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2352 -
val_loss: 0.2279
Epoch 5/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2199 -
val_loss: 0.2124
Epoch 6/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2076 -
val_loss: 0.2032
Epoch 7/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1990 -
val_loss: 0.1954
Epoch 8/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1937 -
val_loss: 0.1918
Epoch 9/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1891 -
val_loss: 0.1865
Epoch 10/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1848 -
val_loss: 0.1818
Epoch 11/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1804 -
val_loss: 0.1786
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1759 -
val_loss: 0.1714
Epoch 13/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1720 -
val_loss: 0.1686
Epoch 14/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1693 -
val_loss: 0.1674
Epoch 15/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1670 -
val_loss: 0.1648
Epoch 16/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1652 -
val_loss: 0.1633
Epoch 17/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1635 -
val_loss: 0.1624
Epoch 18/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1619 -
val_loss: 0.1602
Epoch 19/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1606 -
val_loss: 0.1594
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1592 -
val_loss: 0.1572
Epoch 21/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1580 -
val_loss: 0.1564
Epoch 22/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1567 -
val_loss: 0.1573
Epoch 23/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1555 -
val_loss: 0.1547
Epoch 24/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1541 -
val_loss: 0.1530
Epoch 25/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1527 -
val_loss: 0.1510
Epoch 26/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1515 -
val_loss: 0.1511
Epoch 27/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1502 -
val_loss: 0.1500
Epoch 28/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1492 -
val_loss: 0.1501
Epoch 29/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1480 -
val_loss: 0.1467
Epoch 30/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1471 -
val_loss: 0.1465
Epoch 31/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1462 -
val_loss: 0.1467
Epoch 32/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1453 -
val_loss: 0.1440
Epoch 33/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1443 -
val_loss: 0.1442
Epoch 34/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1433 -
val_loss: 0.1408
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1421 -
val_loss: 0.1416
Epoch 36/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1412 -
val_loss: 0.1403
Epoch 37/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1402 -
val_loss: 0.1394
Epoch 38/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1394 -
val_loss: 0.1377
Epoch 39/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1387 -
val_loss: 0.1386
Epoch 40/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1381 -
val_loss: 0.1373
Epoch 41/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1375 -
val_loss: 0.1372
Epoch 42/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1370 -
val_loss: 0.1350
Epoch 43/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1364 -
val_loss: 0.1354
Epoch 44/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1359 -
val_loss: 0.1350
Epoch 45/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1354 -
val_loss: 0.1353
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1350 -
val_loss: 0.1352
Epoch 47/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1345 -
val_loss: 0.1339
Epoch 48/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1342 -
val_loss: 0.1330
Epoch 49/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1338 -
val_loss: 0.1329
Epoch 50/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1334 -
val_loss: 0.1324
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1330 -
val_loss: 0.1331
Epoch 52/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1327 -
val_loss: 0.1312
Epoch 53/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1323 -
val_loss: 0.1320
Epoch 54/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1319 -
val_loss: 0.1324
Epoch 55/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1315 -
val_loss: 0.1296
Epoch 56/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1312 -
val_loss: 0.1300
Epoch 57/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1309 -
val_loss: 0.1308
Epoch 58/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1304 -
val_loss: 0.1308
Epoch 59/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1300 -
val_loss: 0.1292
Epoch 60/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1295 -
val_loss: 0.1292
Epoch 61/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1291 -
val_loss: 0.1279
Epoch 62/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1287 -
val_loss: 0.1273
Epoch 63/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1282 -
val_loss: 0.1274
Epoch 64/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1279 -
val_loss: 0.1269
Epoch 65/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1274 -
val_loss: 0.1265
Epoch 66/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1271 -
val_loss: 0.1274
Epoch 67/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1268 -
val_loss: 0.1263
Epoch 68/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1265 -
val_loss: 0.1253
Epoch 69/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1261 -
val_loss: 0.1261
Epoch 70/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1258 -
val_loss: 0.1246
Epoch 71/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1256 -
val_loss: 0.1257
Epoch 72/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1254 -
val_loss: 0.1244
Epoch 73/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1250 -
val_loss: 0.1247
Epoch 74/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1249 -
val_loss: 0.1245
Epoch 75/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1245 -
val_loss: 0.1249
Epoch 76/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1243 -
val_loss: 0.1242
Epoch 77/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1241 -
val_loss: 0.1247
Epoch 78/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1238 -
val_loss: 0.1242
Epoch 79/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1237 -
val_loss: 0.1234
Epoch 80/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1235 -
val_loss: 0.1225
Epoch 81/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1233 -
val_loss: 0.1244
Epoch 82/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1232 -
val_loss: 0.1226
Epoch 83/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1229 -
val_loss: 0.1233
Epoch 84/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1228 -
val_loss: 0.1224
Epoch 85/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1226 -
val_loss: 0.1236
Epoch 86/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1224 -
val_loss: 0.1223
Epoch 87/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1222 -
val_loss: 0.1224
Epoch 88/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1219 -
val_loss: 0.1220
Epoch 89/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1218 -
val_loss: 0.1228
Epoch 90/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1217 -
val_loss: 0.1213
Epoch 91/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1215 -
val_loss: 0.1217
Epoch 92/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1214 -
val_loss: 0.1209
Epoch 93/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1211 -
val_loss: 0.1217
Epoch 94/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1210 -
val_loss: 0.1210
Epoch 95/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1209 -
val_loss: 0.1216
Epoch 96/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1208 -
val_loss: 0.1214
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1206 -
val_loss: 0.1209
Epoch 98/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1204 -
val_loss: 0.1206
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1203 -
val_loss: 0.1199
Epoch 100/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1201 -
val_loss: 0.1207
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 4s 75us/step - loss: 0.3360 -
val_loss: 0.2628
Epoch 2/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2568 -
val_loss: 0.2497
Epoch 3/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2434 -
val_loss: 0.2371
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2286 -
val_loss: 0.2191
Epoch 5/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.2098 -
val_loss: 0.2033
Epoch 6/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1977 -
val_loss: 0.1907
Epoch 7/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.1870 -
val_loss: 0.1839
Epoch 8/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1800 -
val_loss: 0.1756
```

```
Epoch 9/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1749 -
val_loss: 0.1706
Epoch 10/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1706 -
val_loss: 0.1677
Epoch 11/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1664 -
val_loss: 0.1625
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1623 -
val_loss: 0.1583
Epoch 13/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1592 -
val_loss: 0.1565
Epoch 14/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1564 -
val_loss: 0.1545
Epoch 15/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1537 -
val_loss: 0.1516
Epoch 16/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1511 -
val_loss: 0.1478
Epoch 17/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1482 -
val_loss: 0.1451
Epoch 18/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1456 -
val_loss: 0.1439
Epoch 19/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1435 -
val_loss: 0.1420
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1415 -
val_loss: 0.1392
Epoch 21/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1398 -
val_loss: 0.1380
Epoch 22/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1384 -
val_loss: 0.1360
Epoch 23/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1372 -
val_loss: 0.1364
Epoch 24/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1361 -
val_loss: 0.1338
```

```
Epoch 25/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1349 -
val_loss: 0.1334
Epoch 26/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1341 -
val_loss: 0.1324
Epoch 27/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1332 -
val_loss: 0.1324
Epoch 28/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1323 -
val_loss: 0.1299
Epoch 29/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1316 -
val_loss: 0.1319
Epoch 30/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1308 -
val_loss: 0.1289
Epoch 31/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1301 -
val_loss: 0.1291
Epoch 32/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1295 -
val_loss: 0.1278
Epoch 33/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1288 -
val_loss: 0.1284
Epoch 34/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1282 -
val_loss: 0.1278
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1277 -
val_loss: 0.1263
Epoch 36/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1271 -
val_loss: 0.1255
Epoch 37/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1265 -
val_loss: 0.1258
Epoch 38/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1261 -
val_loss: 0.1253
Epoch 39/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1255 -
val_loss: 0.1254
Epoch 40/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1251 -
val_loss: 0.1240
```

```
Epoch 41/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1247 -
val_loss: 0.1235
Epoch 42/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1243 -
val_loss: 0.1241
Epoch 43/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1239 -
val_loss: 0.1233
Epoch 44/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1235 -
val_loss: 0.1224
Epoch 45/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1232 -
val_loss: 0.1228
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1227 -
val_loss: 0.1221
Epoch 47/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1223 -
val_loss: 0.1217
Epoch 48/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1220 -
val_loss: 0.1216
Epoch 49/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1217 -
val_loss: 0.1210
Epoch 50/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1213 -
val_loss: 0.1195
Epoch 51/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1208 -
val_loss: 0.1199
Epoch 52/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1205 -
val_loss: 0.1201
Epoch 53/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1202 -
val_loss: 0.1186
Epoch 54/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1198 -
val_loss: 0.1192
Epoch 55/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1194 -
val_loss: 0.1187
Epoch 56/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1191 -
val_loss: 0.1180
```

```
Epoch 57/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1186 -
val_loss: 0.1175
Epoch 58/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1182 -
val_loss: 0.1176
Epoch 59/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1179 -
val_loss: 0.1179
Epoch 60/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1176 -
val_loss: 0.1161
Epoch 61/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1172 -
val_loss: 0.1159
Epoch 62/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1170 -
val_loss: 0.1168
Epoch 63/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1166 -
val_loss: 0.1163
Epoch 64/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1164 -
val_loss: 0.1150
Epoch 65/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1160 -
val_loss: 0.1171
Epoch 66/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1160 -
val_loss: 0.1156
Epoch 67/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1156 -
val_loss: 0.1148
Epoch 68/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1154 -
val_loss: 0.1140
Epoch 69/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1151 -
val_loss: 0.1142
Epoch 70/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1151 -
val_loss: 0.1138
Epoch 71/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1147 -
val_loss: 0.1142
Epoch 72/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1146 -
val_loss: 0.1136
```

```
Epoch 73/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1144 -
val_loss: 0.1150
Epoch 74/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1140 -
val_loss: 0.1140
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1139 -
val_loss: 0.1132
Epoch 76/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1137 -
val_loss: 0.1130
Epoch 77/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1135 -
val_loss: 0.1134
Epoch 78/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1133 -
val_loss: 0.1143
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1131 -
val_loss: 0.1121
Epoch 80/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1129 -
val_loss: 0.1130
Epoch 81/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.1127 -
val_loss: 0.1127
Epoch 82/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1125 -
val_loss: 0.1127
Epoch 83/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1125 -
val_loss: 0.1125
Epoch 84/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1123 -
val_loss: 0.1112
Epoch 85/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1122 -
val_loss: 0.1111
Epoch 86/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1120 -
val_loss: 0.1113
Epoch 87/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1117 -
val_loss: 0.1107
Epoch 88/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1116 -
val_loss: 0.1112
```

```
Epoch 89/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1115 -
val_loss: 0.1112
Epoch 90/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1113 -
val_loss: 0.1107
Epoch 91/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1112 -
val_loss: 0.1103
Epoch 92/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1109 -
val_loss: 0.1108
Epoch 93/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1110 -
val_loss: 0.1105
Epoch 94/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1107 -
val_loss: 0.1115
Epoch 95/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1106 -
val_loss: 0.1106
Epoch 96/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1104 -
val_loss: 0.1101
Epoch 97/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1103 -
val_loss: 0.1092
Epoch 98/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1103 -
val_loss: 0.1102
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1100 -
val_loss: 0.1095
Epoch 100/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1100 -
val_loss: 0.1100
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 5s 79us/step - loss: 0.3292 -
val_loss: 0.2648
Epoch 2/100
60000/60000 [==============================] - 3s 51us/step - loss: 0.2584 -
val_loss: 0.2535
Epoch 3/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.2452 -
val_loss: 0.2385
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2324 -
```

```
val_loss: 0.2256
Epoch 5/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2186 -
val_loss: 0.2114
Epoch 6/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2038 -
val_loss: 0.1987
Epoch 7/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1937 -
val_loss: 0.1917
Epoch 8/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1870 -
val_loss: 0.1837
Epoch 9/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1812 -
val_loss: 0.1790
Epoch 10/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1755 -
val_loss: 0.1734
Epoch 11/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1704 -
val_loss: 0.1679
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1657 -
val_loss: 0.1608
Epoch 13/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1617 -
val_loss: 0.1593
Epoch 14/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1584 -
val_loss: 0.1549
Epoch 15/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1556 -
val_loss: 0.1533
Epoch 16/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1530 -
val_loss: 0.1513
Epoch 17/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1506 -
val_loss: 0.1472
Epoch 18/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1486 -
val_loss: 0.1473
Epoch 19/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1466 -
val_loss: 0.1454
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1450 -
```

```
val_loss: 0.1432
Epoch 21/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1434 -
val_loss: 0.1421
Epoch 22/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1420 -
val_loss: 0.1397
Epoch 23/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1406 -
val_loss: 0.1395
Epoch 24/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1395 -
val_loss: 0.1392
Epoch 25/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1384 -
val_loss: 0.1372
Epoch 26/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1374 -
val_loss: 0.1354
Epoch 27/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1364 -
val_loss: 0.1357
Epoch 28/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1355 -
val_loss: 0.1349
Epoch 29/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1346 -
val_loss: 0.1333
Epoch 30/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1340 -
val_loss: 0.1329
Epoch 31/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1332 -
val_loss: 0.1331
Epoch 32/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1325 -
val_loss: 0.1318
Epoch 33/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1317 -
val_loss: 0.1312
Epoch 34/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1311 -
val_loss: 0.1293
Epoch 35/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1305 -
val_loss: 0.1309
Epoch 36/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1299 -
```

```
val_loss: 0.1294
Epoch 37/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1293 -
val_loss: 0.1284
Epoch 38/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1289 -
val_loss: 0.1307
Epoch 39/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1282 -
val_loss: 0.1281
Epoch 40/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1279 -
val_loss: 0.1264
Epoch 41/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1274 -
val_loss: 0.1265
Epoch 42/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1269 -
val_loss: 0.1252
Epoch 43/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1265 -
val_loss: 0.1246
Epoch 44/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1260 -
val_loss: 0.1248
Epoch 45/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1257 -
val_loss: 0.1249
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1252 -
val_loss: 0.1245
Epoch 47/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1249 -
val_loss: 0.1245
Epoch 48/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1245 -
val_loss: 0.1233
Epoch 49/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1242 -
val_loss: 0.1238
Epoch 50/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1239 -
val_loss: 0.1229
Epoch 51/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1235 -
val_loss: 0.1219
Epoch 52/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1232 -
```

```
val_loss: 0.1234
Epoch 53/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1229 -
val_loss: 0.1224
Epoch 54/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1226 -
val_loss: 0.1212
Epoch 55/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1223 -
val_loss: 0.1223
Epoch 56/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1220 -
val_loss: 0.1221
Epoch 57/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1218 -
val_loss: 0.1209
Epoch 58/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1214 -
val_loss: 0.1214
Epoch 59/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1212 -
val_loss: 0.1215
Epoch 60/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1210 -
val_loss: 0.1212
Epoch 61/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1206 -
val_loss: 0.1204
Epoch 62/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1205 -
val_loss: 0.1200
Epoch 63/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1203 -
val_loss: 0.1203
Epoch 64/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1201 -
val_loss: 0.1192
Epoch 65/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1198 -
val_loss: 0.1192
Epoch 66/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1195 -
val_loss: 0.1196
Epoch 67/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1194 -
val_loss: 0.1203
Epoch 68/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1192 -
```

```
val_loss: 0.1185
Epoch 69/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1189 -
val_loss: 0.1190
Epoch 70/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1186 -
val_loss: 0.1185
Epoch 71/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1184 -
val_loss: 0.1194
Epoch 72/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1184 -
val_loss: 0.1190
Epoch 73/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1182 -
val_loss: 0.1173
Epoch 74/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1180 -
val_loss: 0.1173
Epoch 75/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1178 -
val_loss: 0.1199
Epoch 76/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1176 -
val_loss: 0.1170
Epoch 77/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1174 -
val_loss: 0.1168
Epoch 78/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1173 -
val_loss: 0.1170
Epoch 79/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1170 -
val_loss: 0.1159
Epoch 80/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1169 -
val_loss: 0.1186
Epoch 81/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1168 -
val_loss: 0.1161
Epoch 82/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1166 -
val_loss: 0.1165
Epoch 83/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1165 -
val_loss: 0.1169
Epoch 84/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1163 -
```

```
val_loss: 0.1160
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1159 -
val_loss: 0.1167
Epoch 86/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1161 -
val_loss: 0.1157
Epoch 87/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1158 -
val_loss: 0.1158
Epoch 88/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1157 -
val_loss: 0.1154
Epoch 89/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1155 -
val_loss: 0.1149
Epoch 90/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1154 -
val_loss: 0.1152
Epoch 91/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1152 -
val_loss: 0.1144
Epoch 92/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1152 -
val_loss: 0.1159
Epoch 93/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1150 -
val_loss: 0.1146
Epoch 94/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1148 -
val_loss: 0.1154
Epoch 95/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1149 -
val_loss: 0.1142
Epoch 96/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1147 -
val_loss: 0.1148
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1145 -
val_loss: 0.1144
Epoch 98/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1144 -
val_loss: 0.1152
Epoch 99/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1142 -
val_loss: 0.1141
Epoch 100/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1141 -
```

```
val_loss: 0.1145
Train on 60000 samples, validate on 10000 samples
Epoch 1/100
60000/60000 [==============================] - 5s 77us/step - loss: 0.3218 -
val_loss: 0.2632
Epoch 2/100
60000/60000 [==============================] - 3s 49us/step - loss: 0.2577 -
val_loss: 0.2535
Epoch 3/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.2420 -
val_loss: 0.2303
Epoch 4/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2217 -
val_loss: 0.2120
Epoch 5/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.2050 -
val_loss: 0.1965
Epoch 6/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1935 -
val_loss: 0.1874
Epoch 7/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1845 -
val_loss: 0.1801
Epoch 8/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1763 -
val_loss: 0.1716
Epoch 9/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1697 -
val_loss: 0.1655
Epoch 10/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1643 -
val_loss: 0.1622
Epoch 11/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1594 -
val_loss: 0.1553
Epoch 12/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1553 -
val_loss: 0.1518
Epoch 13/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1517 -
val_loss: 0.1482
Epoch 14/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1491 -
val_loss: 0.1470
Epoch 15/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1466 -
val_loss: 0.1426
Epoch 16/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1444 -
val_loss: 0.1432
Epoch 17/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1420 -
val_loss: 0.1400
Epoch 18/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1399 -
val_loss: 0.1380
Epoch 19/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1377 -
val_loss: 0.1369
Epoch 20/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1362 -
val_loss: 0.1353
Epoch 21/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1348 -
val_loss: 0.1330
Epoch 22/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1334 -
val_loss: 0.1319
Epoch 23/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1322 -
val_loss: 0.1302
Epoch 24/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1311 -
val_loss: 0.1292
Epoch 25/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1300 -
val_loss: 0.1285
Epoch 26/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1290 -
val_loss: 0.1273
Epoch 27/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1281 -
val_loss: 0.1261
Epoch 28/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1272 -
val_loss: 0.1253
Epoch 29/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1262 -
val_loss: 0.1253
Epoch 30/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1253 -
val_loss: 0.1249
Epoch 31/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1244 -
val_loss: 0.1226
Epoch 32/100
```

```
60000/60000 [==============================] - 3s 52us/step - loss: 0.1235 -
val_loss: 0.1224
Epoch 33/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1227 -
val_loss: 0.1202
Epoch 34/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1220 -
val_loss: 0.1196
Epoch 35/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1212 -
val_loss: 0.1193
Epoch 36/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1206 -
val_loss: 0.1180
Epoch 37/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1199 -
val_loss: 0.1189
Epoch 38/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1193 -
val_loss: 0.1183
Epoch 39/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1186 -
val_loss: 0.1177
Epoch 40/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1181 -
val_loss: 0.1173
Epoch 41/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1175 -
val_loss: 0.1160
Epoch 42/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1172 -
val_loss: 0.1151
Epoch 43/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1165 -
val_loss: 0.1156
Epoch 44/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1161 -
val_loss: 0.1144
Epoch 45/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1157 -
val_loss: 0.1158
Epoch 46/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1152 -
val_loss: 0.1136
Epoch 47/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1148 -
val_loss: 0.1151
Epoch 48/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1144 -
val_loss: 0.1138
Epoch 49/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1139 -
val_loss: 0.1132
Epoch 50/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1136 -
val_loss: 0.1121
Epoch 51/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1132 -
val_loss: 0.1123
Epoch 52/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1128 -
val_loss: 0.1118
Epoch 53/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.1123 -
val_loss: 0.1105
Epoch 54/100
60000/60000 [==============================] - 3s 58us/step - loss: 0.1120 -
val_loss: 0.1108
Epoch 55/100
60000/60000 [==============================] - 3s 56us/step - loss: 0.1117 -
val_loss: 0.1113
Epoch 56/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1113 -
val_loss: 0.1102
Epoch 57/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1110 -
val_loss: 0.1106
Epoch 58/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1107 -
val_loss: 0.1102
Epoch 59/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1104 -
val_loss: 0.1095
Epoch 60/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1100 -
val_loss: 0.1081
Epoch 61/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1098 -
val_loss: 0.1107
Epoch 62/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1095 -
val_loss: 0.1084
Epoch 63/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1092 -
val_loss: 0.1077
Epoch 64/100
```

```
60000/60000 [==============================] - 3s 54us/step - loss: 0.1089 -
val_loss: 0.1078
Epoch 65/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1087 -
val_loss: 0.1089
Epoch 66/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1085 -
val_loss: 0.1104
Epoch 67/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1081 -
val_loss: 0.1079
Epoch 68/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1079 -
val_loss: 0.1068
Epoch 69/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1077 -
val_loss: 0.1067
Epoch 70/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1075 -
val_loss: 0.1069
Epoch 71/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1073 -
val_loss: 0.1070
Epoch 72/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1071 -
val_loss: 0.1058
Epoch 73/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1069 -
val_loss: 0.1061
Epoch 74/100
60000/60000 [==============================] - 3s 55us/step - loss: 0.1067 -
val_loss: 0.1064
Epoch 75/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1065 -
val_loss: 0.1064
Epoch 76/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1063 -
val_loss: 0.1056
Epoch 77/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1061 -
val_loss: 0.1060
Epoch 78/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1060 -
val_loss: 0.1052
Epoch 79/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1058 -
val_loss: 0.1061
Epoch 80/100
```

```
60000/60000 [==============================] - 3s 53us/step - loss: 0.1056 -
val_loss: 0.1047
Epoch 81/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1054 -
val_loss: 0.1045
Epoch 82/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1053 -
val_loss: 0.1047
Epoch 83/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1050 -
val_loss: 0.1045
Epoch 84/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1049 -
val_loss: 0.1051
Epoch 85/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1048 -
val_loss: 0.1045
Epoch 86/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1046 -
val_loss: 0.1048
Epoch 87/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1044 -
val_loss: 0.1040
Epoch 88/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1042 -
val_loss: 0.1036
Epoch 89/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1041 -
val_loss: 0.1041
Epoch 90/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1041 -
val_loss: 0.1041
Epoch 91/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1038 -
val_loss: 0.1039
Epoch 92/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1038 -
val_loss: 0.1036
Epoch 93/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1036 -
val_loss: 0.1023
Epoch 94/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1034 -
val_loss: 0.1035
Epoch 95/100
60000/60000 [==============================] - 3s 52us/step - loss: 0.1034 -
val_loss: 0.1023
Epoch 96/100
```

```
60000/60000 [==============================] - 3s 54us/step - loss: 0.1031 -
val_loss: 0.1026
Epoch 97/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1031 -
val_loss: 0.1023
Epoch 98/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1029 -
val_loss: 0.1032
Epoch 99/100
60000/60000 [==============================] - 3s 53us/step - loss: 0.1029 -
val_loss: 0.1019
Epoch 100/100
60000/60000 [==============================] - 3s 54us/step - loss: 0.1027 -
val_loss: 0.1030
```

[133]:
```
loss_score,loss_score_noise
```

[133]:
```
({2: 0.19573124536673228,
  4: 0.15351997696956,
  6: 0.14371606947580973,
  8: 0.12235987691084543,
  10: 0.11384244225819906,
  12: 0.10793483013709386,
  14: 0.10745247059265772,
  16: 0.1057592625617981},
 {2: 0.20028356336752573,
  4: 0.15801826189359028,
  6: 0.14310619707107544,
  8: 0.13236936440467834,
  10: 0.12814583059151968,
  12: 0.11356325762669245,
  14: 0.11811600044171015,
  16: 0.10873440016508103})
```

[156]:
```
encoded_imgs = encoder.predict(xtest)
decoded_imgs = decoder.predict(encoded_imgs)
import matplotlib.pyplot as plt

n = 20  # how many digits we will display
plt.figure(figsize=(40, 4))
for i in range(n):
    # display original
    ax = plt.subplot(2, n, i + 1)
    plt.imshow(xtest[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)
```

```
    # display reconstruction
    ax = plt.subplot(2, n, i + 1 + n)
    plt.imshow(decoded_imgs[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)
plt.show()
```

[ ]: