Experiment_Activation_Functions

July 22, 2021

1 Example code for search of best activation function

1.0.1 ——>ML From Scratch

We are going to run a small experiment, using mostly Keras and Scikit-Learn. The goal is to take the MNIST dataset and draw a graph of activations functions with loss over time.

The outline for this notebook is as follows: 1. Importing packages and small tweaks to MNIST dataset 2. Readying functions, hyperparameters etc. 3. Fitting data 4. Plotting

2 1. Importing and preprocessing

[1]:
```
# IMPORTS
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from keras.datasets import mnist
from keras.utils.np_utils import to_categorical
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten, Conv2D, MaxPooling2D,␣
↪Activation, LeakyReLU
from keras.layers.noise import AlphaDropout
from keras.utils.generic_utils import get_custom_objects
from keras import backend as K
from keras.optimizers import Adam

# LOAD DATA
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# PREPROCESSING
def preprocess_mnist(x_train, y_train, x_test, y_test):
    # Normalizing all images of 28x28 pixels
    x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
    x_test = x_test.reshape(x_test.shape[0], 28, 28, 1)
    input_shape = (28, 28, 1)

    # Float values for division
    x_train = x_train.astype('float32')
```

```
    x_test = x_test.astype('float32')

    # Normalizing the RGB codes by dividing it to the max RGB value
    x_train /= 255
    x_test /= 255

    # Categorical y values
    y_train = to_categorical(y_train)
    y_test= to_categorical(y_test)

    return x_train, y_train, x_test, y_test, input_shape

x_train, y_train, x_test, y_test, input_shape = preprocess_mnist(x_train,␣
 ↪y_train, x_test, y_test)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
11493376/11490434 [==============================] - 1s 0us/step
```

3 2. Readying functions and hyperparameters

[2]:
```
# Readying neural network model
def build_cnn(activation,
              dropout_rate,
              optimizer):
    model = Sequential()

    if(activation == 'selu'):
        model.add(Conv2D(32, kernel_size=(3, 3),
                  activation=activation,
                  input_shape=input_shape,
                  kernel_initializer='lecun_normal'))
        model.add(Conv2D(64, (3, 3), activation=activation,
                         kernel_initializer='lecun_normal'))
        model.add(MaxPooling2D(pool_size=(2, 2)))
        model.add(AlphaDropout(0.25))
        model.add(Flatten())
        model.add(Dense(128, activation=activation,
                        kernel_initializer='lecun_normal'))
        model.add(AlphaDropout(0.5))
        model.add(Dense(10, activation='softmax'))
    else:
        model.add(Conv2D(32, kernel_size=(3, 3),
                  activation=activation,
                  input_shape=input_shape))
        model.add(Conv2D(64, (3, 3), activation=activation))
```

```
        model.add(MaxPooling2D(pool_size=(2, 2)))
        model.add(Dropout(0.25))
        model.add(Flatten())
        model.add(Dense(128, activation=activation))
        model.add(Dropout(0.5))
        model.add(Dense(10, activation='softmax'))

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

    return model

# Add the GELU function to Keras
def gelu(x):
    return 0.5 * x * (1 + tf.tanh(tf.sqrt(2 / np.pi) * (x + 0.044715 * tf.
 ↪pow(x, 3))))
get_custom_objects().update({'gelu': Activation(gelu)})

# Add leaky-relu so we can use it as a string
get_custom_objects().update({'leaky-relu': Activation(LeakyReLU(alpha=0.2))})

act_func = ['sigmoid', 'relu', 'elu', 'leaky-relu', 'selu', 'gelu']
```

4 3. Fitting the data with multiple activation functions

[3]:
```
result = []

for activation in act_func:
    print('\nTraining with -->{0}<-- activation function\n'.format(activation))

    model = build_cnn(activation=activation,
                      dropout_rate=0.2,
                      optimizer=Adam(clipvalue=0.5))

    history = model.fit(x_train, y_train,
          validation_split=0.20,
          batch_size=128, # 128 is faster, but less accurate. 16/32 recommended
          epochs=100,
          verbose=1,
          validation_data=(x_test, y_test))

    result.append(history)
```

```
    K.clear_session()
    del model

print(result)
```

```
Training with -->sigmoid<-- activation function

Epoch 1/100
375/375 [==============================] - 15s 38ms/step - loss: 0.3787 -
accuracy: 0.0986 - val_loss: 0.3253 - val_accuracy: 0.1035
Epoch 2/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3366 -
accuracy: 0.0982 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 3/100
375/375 [==============================] - 15s 40ms/step - loss: 0.3313 -
accuracy: 0.1028 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 4/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3301 -
accuracy: 0.1033 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 5/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3295 -
accuracy: 0.1071 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 6/100
375/375 [==============================] - 15s 39ms/step - loss: 0.3294 -
accuracy: 0.1089 - val_loss: 0.3253 - val_accuracy: 0.0998
Epoch 7/100
375/375 [==============================] - 14s 39ms/step - loss: 0.3290 -
accuracy: 0.1083 - val_loss: 0.3252 - val_accuracy: 0.1081
Epoch 8/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3288 -
accuracy: 0.1058 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 9/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3286 -
accuracy: 0.1074 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 10/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3285 -
accuracy: 0.1073 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 11/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3284 -
accuracy: 0.1086 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 12/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3282 -
accuracy: 0.1038 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 13/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3280 -
accuracy: 0.1082 - val_loss: 0.3251 - val_accuracy: 0.0989
```

```
Epoch 14/100
375/375 [==============================] - 15s 40ms/step - loss: 0.3279 -
accuracy: 0.1056 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 15/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3277 -
accuracy: 0.1040 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 16/100
375/375 [==============================] - 15s 41ms/step - loss: 0.3276 -
accuracy: 0.1045 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 17/100
375/375 [==============================] - 15s 40ms/step - loss: 0.3275 -
accuracy: 0.1060 - val_loss: 0.3255 - val_accuracy: 0.1060
Epoch 18/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3274 -
accuracy: 0.1068 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 19/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3273 -
accuracy: 0.1089 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 20/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3271 -
accuracy: 0.1025 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 21/100
375/375 [==============================] - 15s 39ms/step - loss: 0.3270 -
accuracy: 0.1047 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 22/100
375/375 [==============================] - 15s 41ms/step - loss: 0.3270 -
accuracy: 0.1070 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 23/100
375/375 [==============================] - 15s 40ms/step - loss: 0.3269 -
accuracy: 0.1038 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 24/100
375/375 [==============================] - 15s 40ms/step - loss: 0.3268 -
accuracy: 0.1059 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 25/100
375/375 [==============================] - 15s 39ms/step - loss: 0.3267 -
accuracy: 0.1091 - val_loss: 0.3252 - val_accuracy: 0.0997
Epoch 26/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3267 -
accuracy: 0.1059 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 27/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3265 -
accuracy: 0.1066 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 28/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3265 -
accuracy: 0.1083 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 29/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3263 -
accuracy: 0.1079 - val_loss: 0.3252 - val_accuracy: 0.1060
```

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Epoch 30/100
375/375 [==============================] - 14s 39ms/step - loss: 0.3264 -
accuracy: 0.1076 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 31/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3262 -
accuracy: 0.1086 - val_loss: 0.3254 - val_accuracy: 0.0956
Epoch 32/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3262 -
accuracy: 0.1082 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 33/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3262 -
accuracy: 0.1075 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 34/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3262 -
accuracy: 0.1053 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 35/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3261 -
accuracy: 0.1068 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 36/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3260 -
accuracy: 0.1081 - val_loss: 0.3250 - val_accuracy: 0.1060
Epoch 37/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3261 -
accuracy: 0.1075 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 38/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3260 -
accuracy: 0.1055 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 39/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3259 -
accuracy: 0.1082 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 40/100
375/375 [==============================] - 15s 39ms/step - loss: 0.3259 -
accuracy: 0.1095 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 41/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3259 -
accuracy: 0.1055 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 42/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3258 -
accuracy: 0.1086 - val_loss: 0.3252 - val_accuracy: 0.1081
Epoch 43/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3259 -
accuracy: 0.1061 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 44/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3258 -
accuracy: 0.1054 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 45/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3257 -
accuracy: 0.1047 - val_loss: 0.3253 - val_accuracy: 0.1060
```

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Epoch 46/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3256 -
accuracy: 0.1116 - val_loss: 0.3252 - val_accuracy: 0.1035
Epoch 47/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3258 -
accuracy: 0.1042 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 48/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3256 -
accuracy: 0.1110 - val_loss: 0.3251 - val_accuracy: 0.1035
Epoch 49/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3257 -
accuracy: 0.1057 - val_loss: 0.3253 - val_accuracy: 0.0956
Epoch 50/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3257 -
accuracy: 0.1081 - val_loss: 0.3251 - val_accuracy: 0.0995
Epoch 51/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3256 -
accuracy: 0.1084 - val_loss: 0.3252 - val_accuracy: 0.1035
Epoch 52/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3257 -
accuracy: 0.1031 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 53/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1108 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 54/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3256 -
accuracy: 0.1076 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 55/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3256 -
accuracy: 0.1079 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 56/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1103 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 57/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3255 -
accuracy: 0.1061 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 58/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1084 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 59/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1062 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 60/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1077 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 61/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1098 - val_loss: 0.3251 - val_accuracy: 0.1060
```

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Epoch 62/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3255 -
accuracy: 0.1085 - val_loss: 0.3251 - val_accuracy: 0.0995
Epoch 63/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1072 - val_loss: 0.3251 - val_accuracy: 0.0989
Epoch 64/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1078 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 65/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1094 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 66/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1115 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 67/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1144 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 68/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3255 -
accuracy: 0.1069 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 69/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3255 -
accuracy: 0.1048 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 70/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3255 -
accuracy: 0.1087 - val_loss: 0.3255 - val_accuracy: 0.1060
Epoch 71/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1119 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 72/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1106 - val_loss: 0.3254 - val_accuracy: 0.1035
Epoch 73/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3255 -
accuracy: 0.1062 - val_loss: 0.3251 - val_accuracy: 0.0956
Epoch 74/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1090 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 75/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1116 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 76/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1076 - val_loss: 0.3251 - val_accuracy: 0.0956
Epoch 77/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1063 - val_loss: 0.3254 - val_accuracy: 0.0975
```

```
Epoch 78/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1074 - val_loss: 0.3253 - val_accuracy: 0.0956
Epoch 79/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1083 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 80/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1079 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 81/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1061 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 82/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1083 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 83/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1072 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 84/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3254 -
accuracy: 0.1075 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 85/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3254 -
accuracy: 0.1056 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 86/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3252 -
accuracy: 0.1060 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 87/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3253 -
accuracy: 0.1077 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 88/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1066 - val_loss: 0.3251 - val_accuracy: 0.1081
Epoch 89/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3253 -
accuracy: 0.1091 - val_loss: 0.3251 - val_accuracy: 0.0956
Epoch 90/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1061 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 91/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1068 - val_loss: 0.3252 - val_accuracy: 0.1060
Epoch 92/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1107 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 93/100
375/375 [==============================] - 14s 38ms/step - loss: 0.3254 -
accuracy: 0.1074 - val_loss: 0.3252 - val_accuracy: 0.1060
```

```
Epoch 94/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3252 -
accuracy: 0.1083 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 95/100
375/375 [==============================] - 14s 36ms/step - loss: 0.3253 -
accuracy: 0.1083 - val_loss: 0.3253 - val_accuracy: 0.1060
Epoch 96/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3253 -
accuracy: 0.1043 - val_loss: 0.3251 - val_accuracy: 0.1060
Epoch 97/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1041 - val_loss: 0.3254 - val_accuracy: 0.1060
Epoch 98/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1061 - val_loss: 0.3255 - val_accuracy: 0.1060
Epoch 99/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3255 -
accuracy: 0.1050 - val_loss: 0.3255 - val_accuracy: 0.0956
Epoch 100/100
375/375 [==============================] - 14s 37ms/step - loss: 0.3254 -
accuracy: 0.1070 - val_loss: 0.3252 - val_accuracy: 0.1060

Training with -->relu<-- activation function

Epoch 1/100
375/375 [==============================] - 14s 35ms/step - loss: 0.1521 -
accuracy: 0.7290 - val_loss: 0.0173 - val_accuracy: 0.9768
Epoch 2/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0286 -
accuracy: 0.9626 - val_loss: 0.0120 - val_accuracy: 0.9821
Epoch 3/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0210 -
accuracy: 0.9726 - val_loss: 0.0102 - val_accuracy: 0.9848
Epoch 4/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0172 -
accuracy: 0.9789 - val_loss: 0.0097 - val_accuracy: 0.9871
Epoch 5/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0158 -
accuracy: 0.9804 - val_loss: 0.0089 - val_accuracy: 0.9879
Epoch 6/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0131 -
accuracy: 0.9850 - val_loss: 0.0083 - val_accuracy: 0.9892
Epoch 7/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0119 -
accuracy: 0.9854 - val_loss: 0.0080 - val_accuracy: 0.9894
Epoch 8/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0111 -
accuracy: 0.9871 - val_loss: 0.0078 - val_accuracy: 0.9893
```

```
Epoch 9/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0101 -
accuracy: 0.9883 - val_loss: 0.0084 - val_accuracy: 0.9900
Epoch 10/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0091 -
accuracy: 0.9900 - val_loss: 0.0077 - val_accuracy: 0.9900
Epoch 11/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0085 -
accuracy: 0.9899 - val_loss: 0.0076 - val_accuracy: 0.9906
Epoch 12/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0082 -
accuracy: 0.9904 - val_loss: 0.0076 - val_accuracy: 0.9894
Epoch 13/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0080 -
accuracy: 0.9905 - val_loss: 0.0080 - val_accuracy: 0.9900
Epoch 14/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0073 -
accuracy: 0.9919 - val_loss: 0.0082 - val_accuracy: 0.9907
Epoch 15/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0071 -
accuracy: 0.9920 - val_loss: 0.0078 - val_accuracy: 0.9922
Epoch 16/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0064 -
accuracy: 0.9935 - val_loss: 0.0083 - val_accuracy: 0.9903
Epoch 17/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0064 -
accuracy: 0.9931 - val_loss: 0.0077 - val_accuracy: 0.9909
Epoch 18/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0057 -
accuracy: 0.9939 - val_loss: 0.0076 - val_accuracy: 0.9916
Epoch 19/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0058 -
accuracy: 0.9944 - val_loss: 0.0078 - val_accuracy: 0.9908
Epoch 20/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0051 -
accuracy: 0.9948 - val_loss: 0.0088 - val_accuracy: 0.9908
Epoch 21/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0052 -
accuracy: 0.9944 - val_loss: 0.0079 - val_accuracy: 0.9912
Epoch 22/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0051 -
accuracy: 0.9951 - val_loss: 0.0077 - val_accuracy: 0.9912
Epoch 23/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0049 -
accuracy: 0.9952 - val_loss: 0.0087 - val_accuracy: 0.9911
Epoch 24/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0047 -
accuracy: 0.9951 - val_loss: 0.0086 - val_accuracy: 0.9905
```

```
Epoch 25/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0045 -
accuracy: 0.9960 - val_loss: 0.0087 - val_accuracy: 0.9917
Epoch 26/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0047 -
accuracy: 0.9954 - val_loss: 0.0091 - val_accuracy: 0.9907
Epoch 27/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0042 -
accuracy: 0.9959 - val_loss: 0.0084 - val_accuracy: 0.9913
Epoch 28/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0039 -
accuracy: 0.9960 - val_loss: 0.0083 - val_accuracy: 0.9918
Epoch 29/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0041 -
accuracy: 0.9964 - val_loss: 0.0088 - val_accuracy: 0.9921
Epoch 30/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0037 -
accuracy: 0.9963 - val_loss: 0.0091 - val_accuracy: 0.9915
Epoch 31/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0039 -
accuracy: 0.9965 - val_loss: 0.0087 - val_accuracy: 0.9923
Epoch 32/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0036 -
accuracy: 0.9966 - val_loss: 0.0084 - val_accuracy: 0.9922
Epoch 33/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0034 -
accuracy: 0.9970 - val_loss: 0.0083 - val_accuracy: 0.9918
Epoch 34/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0034 -
accuracy: 0.9973 - val_loss: 0.0091 - val_accuracy: 0.9916
Epoch 35/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0032 -
accuracy: 0.9974 - val_loss: 0.0088 - val_accuracy: 0.9919
Epoch 36/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0035 -
accuracy: 0.9969 - val_loss: 0.0097 - val_accuracy: 0.9915
Epoch 37/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0034 -
accuracy: 0.9968 - val_loss: 0.0093 - val_accuracy: 0.9917
Epoch 38/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0031 -
accuracy: 0.9972 - val_loss: 0.0092 - val_accuracy: 0.9920
Epoch 39/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0031 -
accuracy: 0.9970 - val_loss: 0.0092 - val_accuracy: 0.9915
Epoch 40/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0029 -
accuracy: 0.9974 - val_loss: 0.0098 - val_accuracy: 0.9927
```

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Epoch 41/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0031 -
accuracy: 0.9976 - val_loss: 0.0099 - val_accuracy: 0.9916
Epoch 42/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0030 -
accuracy: 0.9973 - val_loss: 0.0095 - val_accuracy: 0.9920
Epoch 43/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0029 -
accuracy: 0.9971 - val_loss: 0.0093 - val_accuracy: 0.9918
Epoch 44/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0032 -
accuracy: 0.9969 - val_loss: 0.0102 - val_accuracy: 0.9917
Epoch 45/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0030 -
accuracy: 0.9970 - val_loss: 0.0103 - val_accuracy: 0.9923
Epoch 46/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0029 -
accuracy: 0.9974 - val_loss: 0.0093 - val_accuracy: 0.9925
Epoch 47/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0028 -
accuracy: 0.9973 - val_loss: 0.0094 - val_accuracy: 0.9927
Epoch 48/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0028 -
accuracy: 0.9976 - val_loss: 0.0098 - val_accuracy: 0.9932
Epoch 49/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0027 -
accuracy: 0.9979 - val_loss: 0.0093 - val_accuracy: 0.9922
Epoch 50/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0026 -
accuracy: 0.9979 - val_loss: 0.0100 - val_accuracy: 0.9924
Epoch 51/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0026 -
accuracy: 0.9978 - val_loss: 0.0107 - val_accuracy: 0.9926
Epoch 52/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0030 -
accuracy: 0.9972 - val_loss: 0.0101 - val_accuracy: 0.9922
Epoch 53/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0024 -
accuracy: 0.9979 - val_loss: 0.0102 - val_accuracy: 0.9927
Epoch 54/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0026 -
accuracy: 0.9977 - val_loss: 0.0100 - val_accuracy: 0.9929
Epoch 55/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0026 -
accuracy: 0.9979 - val_loss: 0.0105 - val_accuracy: 0.9921
Epoch 56/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0027 -
accuracy: 0.9980 - val_loss: 0.0107 - val_accuracy: 0.9921
```

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Epoch 57/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0025 -
accuracy: 0.9975 - val_loss: 0.0101 - val_accuracy: 0.9927
Epoch 58/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0022 -
accuracy: 0.9983 - val_loss: 0.0103 - val_accuracy: 0.9925
Epoch 59/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0022 -
accuracy: 0.9983 - val_loss: 0.0100 - val_accuracy: 0.9927
Epoch 60/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0026 -
accuracy: 0.9972 - val_loss: 0.0104 - val_accuracy: 0.9925
Epoch 61/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0020 -
accuracy: 0.9984 - val_loss: 0.0104 - val_accuracy: 0.9923
Epoch 62/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0023 -
accuracy: 0.9979 - val_loss: 0.0092 - val_accuracy: 0.9929
Epoch 63/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0023 -
accuracy: 0.9984 - val_loss: 0.0102 - val_accuracy: 0.9928
Epoch 64/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9983 - val_loss: 0.0102 - val_accuracy: 0.9925
Epoch 65/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9983 - val_loss: 0.0110 - val_accuracy: 0.9922
Epoch 66/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9985 - val_loss: 0.0100 - val_accuracy: 0.9925
Epoch 67/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0023 -
accuracy: 0.9983 - val_loss: 0.0100 - val_accuracy: 0.9923
Epoch 68/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9980 - val_loss: 0.0110 - val_accuracy: 0.9924
Epoch 69/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0022 -
accuracy: 0.9985 - val_loss: 0.0105 - val_accuracy: 0.9935
Epoch 70/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0021 -
accuracy: 0.9982 - val_loss: 0.0107 - val_accuracy: 0.9924
Epoch 71/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0023 -
accuracy: 0.9980 - val_loss: 0.0108 - val_accuracy: 0.9919
Epoch 72/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0021 -
accuracy: 0.9985 - val_loss: 0.0097 - val_accuracy: 0.9927
```

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Epoch 73/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9985 - val_loss: 0.0108 - val_accuracy: 0.9921
Epoch 74/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9985 - val_loss: 0.0102 - val_accuracy: 0.9929
Epoch 75/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0020 -
accuracy: 0.9983 - val_loss: 0.0105 - val_accuracy: 0.9926
Epoch 76/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0020 -
accuracy: 0.9985 - val_loss: 0.0105 - val_accuracy: 0.9929
Epoch 77/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0020 -
accuracy: 0.9981 - val_loss: 0.0105 - val_accuracy: 0.9923
Epoch 78/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0018 -
accuracy: 0.9988 - val_loss: 0.0099 - val_accuracy: 0.9930
Epoch 79/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0020 -
accuracy: 0.9984 - val_loss: 0.0111 - val_accuracy: 0.9928
Epoch 80/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9986 - val_loss: 0.0114 - val_accuracy: 0.9923
Epoch 81/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0021 -
accuracy: 0.9984 - val_loss: 0.0113 - val_accuracy: 0.9926
Epoch 82/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9985 - val_loss: 0.0113 - val_accuracy: 0.9922
Epoch 83/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9983 - val_loss: 0.0104 - val_accuracy: 0.9930
Epoch 84/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0017 -
accuracy: 0.9987 - val_loss: 0.0109 - val_accuracy: 0.9928
Epoch 85/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0024 -
accuracy: 0.9980 - val_loss: 0.0110 - val_accuracy: 0.9923
Epoch 86/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0015 -
accuracy: 0.9991 - val_loss: 0.0117 - val_accuracy: 0.9925
Epoch 87/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0018 -
accuracy: 0.9988 - val_loss: 0.0108 - val_accuracy: 0.9927
Epoch 88/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0020 -
accuracy: 0.9986 - val_loss: 0.0114 - val_accuracy: 0.9930
```

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Epoch 89/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0019 -
accuracy: 0.9981 - val_loss: 0.0120 - val_accuracy: 0.9930
Epoch 90/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9985 - val_loss: 0.0118 - val_accuracy: 0.9928
Epoch 91/100
375/375 [==============================] - 13s 33ms/step - loss: 0.0018 -
accuracy: 0.9987 - val_loss: 0.0127 - val_accuracy: 0.9932
Epoch 92/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9988 - val_loss: 0.0115 - val_accuracy: 0.9932
Epoch 93/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0019 -
accuracy: 0.9985 - val_loss: 0.0111 - val_accuracy: 0.9927
Epoch 94/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0021 -
accuracy: 0.9981 - val_loss: 0.0109 - val_accuracy: 0.9929
Epoch 95/100
375/375 [==============================] - 13s 35ms/step - loss: 0.0018 -
accuracy: 0.9986 - val_loss: 0.0116 - val_accuracy: 0.9929
Epoch 96/100
375/375 [==============================] - 13s 34ms/step - loss: 0.0018 -
accuracy: 0.9985 - val_loss: 0.0114 - val_accuracy: 0.9933
Epoch 97/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9983 - val_loss: 0.0114 - val_accuracy: 0.9930
Epoch 98/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9985 - val_loss: 0.0122 - val_accuracy: 0.9922
Epoch 99/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0014 -
accuracy: 0.9990 - val_loss: 0.0125 - val_accuracy: 0.9925
Epoch 100/100
375/375 [==============================] - 12s 33ms/step - loss: 0.0018 -
accuracy: 0.9988 - val_loss: 0.0114 - val_accuracy: 0.9925

Training with -->elu<-- activation function

Epoch 1/100
375/375 [==============================] - 14s 37ms/step - loss: 0.1291 -
accuracy: 0.7900 - val_loss: 0.0194 - val_accuracy: 0.9764
Epoch 2/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0308 -
accuracy: 0.9652 - val_loss: 0.0130 - val_accuracy: 0.9818
Epoch 3/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0221 -
accuracy: 0.9756 - val_loss: 0.0128 - val_accuracy: 0.9823
```

```
Epoch 4/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0189 -
accuracy: 0.9789 - val_loss: 0.0112 - val_accuracy: 0.9858
Epoch 5/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0162 -
accuracy: 0.9827 - val_loss: 0.0104 - val_accuracy: 0.9862
Epoch 6/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0142 -
accuracy: 0.9857 - val_loss: 0.0113 - val_accuracy: 0.9861
Epoch 7/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0127 -
accuracy: 0.9866 - val_loss: 0.0108 - val_accuracy: 0.9868
Epoch 8/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0118 -
accuracy: 0.9878 - val_loss: 0.0105 - val_accuracy: 0.9864
Epoch 9/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0108 -
accuracy: 0.9894 - val_loss: 0.0110 - val_accuracy: 0.9870
Epoch 10/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0104 -
accuracy: 0.9891 - val_loss: 0.0101 - val_accuracy: 0.9882
Epoch 11/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0092 -
accuracy: 0.9915 - val_loss: 0.0104 - val_accuracy: 0.9883
Epoch 12/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0089 -
accuracy: 0.9914 - val_loss: 0.0101 - val_accuracy: 0.9884
Epoch 13/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0084 -
accuracy: 0.9925 - val_loss: 0.0109 - val_accuracy: 0.9883
Epoch 14/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0090 -
accuracy: 0.9912 - val_loss: 0.0117 - val_accuracy: 0.9879
Epoch 15/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0073 -
accuracy: 0.9935 - val_loss: 0.0112 - val_accuracy: 0.9878
Epoch 16/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0081 -
accuracy: 0.9929 - val_loss: 0.0108 - val_accuracy: 0.9877
Epoch 17/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0074 -
accuracy: 0.9924 - val_loss: 0.0117 - val_accuracy: 0.9883
Epoch 18/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0071 -
accuracy: 0.9931 - val_loss: 0.0124 - val_accuracy: 0.9883
Epoch 19/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0062 -
accuracy: 0.9947 - val_loss: 0.0119 - val_accuracy: 0.9878
```

```
Epoch 20/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0070 -
accuracy: 0.9934 - val_loss: 0.0110 - val_accuracy: 0.9889
Epoch 21/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0064 -
accuracy: 0.9949 - val_loss: 0.0111 - val_accuracy: 0.9888
Epoch 22/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0067 -
accuracy: 0.9942 - val_loss: 0.0122 - val_accuracy: 0.9876
Epoch 23/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0064 -
accuracy: 0.9943 - val_loss: 0.0117 - val_accuracy: 0.9887
Epoch 24/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0061 -
accuracy: 0.9952 - val_loss: 0.0127 - val_accuracy: 0.9899
Epoch 25/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0059 -
accuracy: 0.9955 - val_loss: 0.0121 - val_accuracy: 0.9891
Epoch 26/100
375/375 [==============================] - 15s 41ms/step - loss: 0.0054 -
accuracy: 0.9957 - val_loss: 0.0127 - val_accuracy: 0.9898
Epoch 27/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0060 -
accuracy: 0.9950 - val_loss: 0.0131 - val_accuracy: 0.9890
Epoch 28/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0060 -
accuracy: 0.9958 - val_loss: 0.0120 - val_accuracy: 0.9883
Epoch 29/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0052 -
accuracy: 0.9953 - val_loss: 0.0126 - val_accuracy: 0.9898
Epoch 30/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0050 -
accuracy: 0.9957 - val_loss: 0.0127 - val_accuracy: 0.9900
Epoch 31/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0053 -
accuracy: 0.9959 - val_loss: 0.0128 - val_accuracy: 0.9890
Epoch 32/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0056 -
accuracy: 0.9955 - val_loss: 0.0132 - val_accuracy: 0.9893
Epoch 33/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0052 -
accuracy: 0.9963 - val_loss: 0.0130 - val_accuracy: 0.9897
Epoch 34/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0045 -
accuracy: 0.9966 - val_loss: 0.0133 - val_accuracy: 0.9894
Epoch 35/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0048 -
accuracy: 0.9965 - val_loss: 0.0121 - val_accuracy: 0.9898
```

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Epoch 36/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0050 -
accuracy: 0.9960 - val_loss: 0.0126 - val_accuracy: 0.9898
Epoch 37/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0043 -
accuracy: 0.9966 - val_loss: 0.0152 - val_accuracy: 0.9883
Epoch 38/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0049 -
accuracy: 0.9965 - val_loss: 0.0134 - val_accuracy: 0.9897
Epoch 39/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0045 -
accuracy: 0.9967 - val_loss: 0.0129 - val_accuracy: 0.9898
Epoch 40/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0046 -
accuracy: 0.9967 - val_loss: 0.0130 - val_accuracy: 0.9900
Epoch 41/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0047 -
accuracy: 0.9963 - val_loss: 0.0135 - val_accuracy: 0.9899
Epoch 42/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0041 -
accuracy: 0.9970 - val_loss: 0.0137 - val_accuracy: 0.9887
Epoch 43/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0049 -
accuracy: 0.9963 - val_loss: 0.0134 - val_accuracy: 0.9896
Epoch 44/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0038 -
accuracy: 0.9971 - val_loss: 0.0142 - val_accuracy: 0.9891
Epoch 45/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0040 -
accuracy: 0.9974 - val_loss: 0.0134 - val_accuracy: 0.9893
Epoch 46/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0043 -
accuracy: 0.9967 - val_loss: 0.0138 - val_accuracy: 0.9887
Epoch 47/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0045 -
accuracy: 0.9972 - val_loss: 0.0140 - val_accuracy: 0.9892
Epoch 48/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0045 -
accuracy: 0.9971 - val_loss: 0.0145 - val_accuracy: 0.9903
Epoch 49/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0048 -
accuracy: 0.9963 - val_loss: 0.0151 - val_accuracy: 0.9897
Epoch 50/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0040 -
accuracy: 0.9971 - val_loss: 0.0136 - val_accuracy: 0.9896
Epoch 51/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0042 -
accuracy: 0.9975 - val_loss: 0.0141 - val_accuracy: 0.9898
```

```
Epoch 52/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0043 -
accuracy: 0.9968 - val_loss: 0.0153 - val_accuracy: 0.9887
Epoch 53/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0038 -
accuracy: 0.9974 - val_loss: 0.0141 - val_accuracy: 0.9893
Epoch 54/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0040 -
accuracy: 0.9971 - val_loss: 0.0148 - val_accuracy: 0.9896
Epoch 55/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0038 -
accuracy: 0.9973 - val_loss: 0.0146 - val_accuracy: 0.9895
Epoch 56/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0038 -
accuracy: 0.9973 - val_loss: 0.0148 - val_accuracy: 0.9890
Epoch 57/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0041 -
accuracy: 0.9972 - val_loss: 0.0146 - val_accuracy: 0.9892
Epoch 58/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0041 -
accuracy: 0.9973 - val_loss: 0.0152 - val_accuracy: 0.9897
Epoch 59/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0041 -
accuracy: 0.9973 - val_loss: 0.0142 - val_accuracy: 0.9902
Epoch 60/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0038 -
accuracy: 0.9970 - val_loss: 0.0156 - val_accuracy: 0.9900
Epoch 61/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0034 -
accuracy: 0.9974 - val_loss: 0.0140 - val_accuracy: 0.9898
Epoch 62/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0040 -
accuracy: 0.9973 - val_loss: 0.0151 - val_accuracy: 0.9898
Epoch 63/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0037 -
accuracy: 0.9975 - val_loss: 0.0147 - val_accuracy: 0.9898
Epoch 64/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0035 -
accuracy: 0.9978 - val_loss: 0.0147 - val_accuracy: 0.9909
Epoch 65/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0042 -
accuracy: 0.9968 - val_loss: 0.0153 - val_accuracy: 0.9893
Epoch 66/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0038 -
accuracy: 0.9977 - val_loss: 0.0135 - val_accuracy: 0.9899
Epoch 67/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0034 -
accuracy: 0.9978 - val_loss: 0.0150 - val_accuracy: 0.9897
```

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Epoch 68/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0035 -
accuracy: 0.9979 - val_loss: 0.0175 - val_accuracy: 0.9893
Epoch 69/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0036 -
accuracy: 0.9978 - val_loss: 0.0162 - val_accuracy: 0.9890
Epoch 70/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0033 -
accuracy: 0.9981 - val_loss: 0.0158 - val_accuracy: 0.9890
Epoch 71/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0033 -
accuracy: 0.9977 - val_loss: 0.0160 - val_accuracy: 0.9893
Epoch 72/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0040 -
accuracy: 0.9976 - val_loss: 0.0166 - val_accuracy: 0.9896
Epoch 73/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0039 -
accuracy: 0.9975 - val_loss: 0.0171 - val_accuracy: 0.9892
Epoch 74/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0037 -
accuracy: 0.9974 - val_loss: 0.0172 - val_accuracy: 0.9895
Epoch 75/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0035 -
accuracy: 0.9977 - val_loss: 0.0164 - val_accuracy: 0.9899
Epoch 76/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0031 -
accuracy: 0.9979 - val_loss: 0.0163 - val_accuracy: 0.9897
Epoch 77/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0034 -
accuracy: 0.9979 - val_loss: 0.0167 - val_accuracy: 0.9896
Epoch 78/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0034 -
accuracy: 0.9979 - val_loss: 0.0175 - val_accuracy: 0.9893
Epoch 79/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0030 -
accuracy: 0.9983 - val_loss: 0.0158 - val_accuracy: 0.9891
Epoch 80/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0034 -
accuracy: 0.9979 - val_loss: 0.0156 - val_accuracy: 0.9889
Epoch 81/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0032 -
accuracy: 0.9981 - val_loss: 0.0176 - val_accuracy: 0.9892
Epoch 82/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9979 - val_loss: 0.0172 - val_accuracy: 0.9901
Epoch 83/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0033 -
accuracy: 0.9984 - val_loss: 0.0169 - val_accuracy: 0.9898
```

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Epoch 84/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0031 -
accuracy: 0.9980 - val_loss: 0.0188 - val_accuracy: 0.9902
Epoch 85/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9974 - val_loss: 0.0190 - val_accuracy: 0.9905
Epoch 86/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0034 -
accuracy: 0.9976 - val_loss: 0.0172 - val_accuracy: 0.9898
Epoch 87/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0033 -
accuracy: 0.9983 - val_loss: 0.0179 - val_accuracy: 0.9899
Epoch 88/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0035 -
accuracy: 0.9980 - val_loss: 0.0158 - val_accuracy: 0.9899
Epoch 89/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0033 -
accuracy: 0.9980 - val_loss: 0.0177 - val_accuracy: 0.9896
Epoch 90/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0035 -
accuracy: 0.9978 - val_loss: 0.0158 - val_accuracy: 0.9898
Epoch 91/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0032 -
accuracy: 0.9981 - val_loss: 0.0173 - val_accuracy: 0.9894
Epoch 92/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0030 -
accuracy: 0.9979 - val_loss: 0.0176 - val_accuracy: 0.9901
Epoch 93/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9976 - val_loss: 0.0168 - val_accuracy: 0.9902
Epoch 94/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0031 -
accuracy: 0.9982 - val_loss: 0.0180 - val_accuracy: 0.9898
Epoch 95/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0029 -
accuracy: 0.9980 - val_loss: 0.0194 - val_accuracy: 0.9888
Epoch 96/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9983 - val_loss: 0.0184 - val_accuracy: 0.9903
Epoch 97/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0028 -
accuracy: 0.9985 - val_loss: 0.0195 - val_accuracy: 0.9880
Epoch 98/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0034 -
accuracy: 0.9974 - val_loss: 0.0174 - val_accuracy: 0.9899
Epoch 99/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0035 -
accuracy: 0.9981 - val_loss: 0.0186 - val_accuracy: 0.9905
```

```
Epoch 100/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0028 -
accuracy: 0.9984 - val_loss: 0.0172 - val_accuracy: 0.9901

Training with -->leaky-relu<-- activation function

Epoch 1/100
375/375 [==============================] - 15s 38ms/step - loss: 0.1356 -
accuracy: 0.7662 - val_loss: 0.0171 - val_accuracy: 0.9787
Epoch 2/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0257 -
accuracy: 0.9699 - val_loss: 0.0125 - val_accuracy: 0.9835
Epoch 3/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0196 -
accuracy: 0.9776 - val_loss: 0.0109 - val_accuracy: 0.9852
Epoch 4/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0163 -
accuracy: 0.9821 - val_loss: 0.0111 - val_accuracy: 0.9860
Epoch 5/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0140 -
accuracy: 0.9852 - val_loss: 0.0093 - val_accuracy: 0.9870
Epoch 6/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0134 -
accuracy: 0.9858 - val_loss: 0.0090 - val_accuracy: 0.9883
Epoch 7/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0111 -
accuracy: 0.9881 - val_loss: 0.0096 - val_accuracy: 0.9878
Epoch 8/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0102 -
accuracy: 0.9899 - val_loss: 0.0090 - val_accuracy: 0.9883
Epoch 9/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0096 -
accuracy: 0.9907 - val_loss: 0.0082 - val_accuracy: 0.9893
Epoch 10/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0091 -
accuracy: 0.9913 - val_loss: 0.0080 - val_accuracy: 0.9898
Epoch 11/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0083 -
accuracy: 0.9919 - val_loss: 0.0081 - val_accuracy: 0.9898
Epoch 12/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0085 -
accuracy: 0.9919 - val_loss: 0.0085 - val_accuracy: 0.9893
Epoch 13/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0079 -
accuracy: 0.9932 - val_loss: 0.0084 - val_accuracy: 0.9893
Epoch 14/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0074 -
accuracy: 0.9929 - val_loss: 0.0080 - val_accuracy: 0.9902
```

```
Epoch 15/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0066 -
accuracy: 0.9943 - val_loss: 0.0079 - val_accuracy: 0.9900
Epoch 16/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0064 -
accuracy: 0.9947 - val_loss: 0.0085 - val_accuracy: 0.9900
Epoch 17/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0064 -
accuracy: 0.9942 - val_loss: 0.0083 - val_accuracy: 0.9906
Epoch 18/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0054 -
accuracy: 0.9954 - val_loss: 0.0096 - val_accuracy: 0.9899
Epoch 19/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0063 -
accuracy: 0.9947 - val_loss: 0.0086 - val_accuracy: 0.9902
Epoch 20/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0059 -
accuracy: 0.9957 - val_loss: 0.0087 - val_accuracy: 0.9905
Epoch 21/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0050 -
accuracy: 0.9964 - val_loss: 0.0081 - val_accuracy: 0.9910
Epoch 22/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0053 -
accuracy: 0.9962 - val_loss: 0.0085 - val_accuracy: 0.9911
Epoch 23/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0048 -
accuracy: 0.9963 - val_loss: 0.0092 - val_accuracy: 0.9899
Epoch 24/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0043 -
accuracy: 0.9973 - val_loss: 0.0091 - val_accuracy: 0.9909
Epoch 25/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0049 -
accuracy: 0.9963 - val_loss: 0.0091 - val_accuracy: 0.9902
Epoch 26/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0042 -
accuracy: 0.9969 - val_loss: 0.0101 - val_accuracy: 0.9904
Epoch 27/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0041 -
accuracy: 0.9974 - val_loss: 0.0092 - val_accuracy: 0.9908
Epoch 28/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0039 -
accuracy: 0.9974 - val_loss: 0.0110 - val_accuracy: 0.9897
Epoch 29/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9978 - val_loss: 0.0092 - val_accuracy: 0.9904
Epoch 30/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0037 -
accuracy: 0.9974 - val_loss: 0.0099 - val_accuracy: 0.9905
```

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Epoch 31/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0036 -
accuracy: 0.9979 - val_loss: 0.0092 - val_accuracy: 0.9911
Epoch 32/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0039 -
accuracy: 0.9976 - val_loss: 0.0093 - val_accuracy: 0.9909
Epoch 33/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0037 -
accuracy: 0.9981 - val_loss: 0.0097 - val_accuracy: 0.9904
Epoch 34/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0036 -
accuracy: 0.9978 - val_loss: 0.0085 - val_accuracy: 0.9920
Epoch 35/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0033 -
accuracy: 0.9979 - val_loss: 0.0092 - val_accuracy: 0.9915
Epoch 36/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0031 -
accuracy: 0.9981 - val_loss: 0.0097 - val_accuracy: 0.9917
Epoch 37/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0030 -
accuracy: 0.9987 - val_loss: 0.0103 - val_accuracy: 0.9906
Epoch 38/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0033 -
accuracy: 0.9981 - val_loss: 0.0103 - val_accuracy: 0.9914
Epoch 39/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0028 -
accuracy: 0.9986 - val_loss: 0.0111 - val_accuracy: 0.9909
Epoch 40/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0030 -
accuracy: 0.9980 - val_loss: 0.0098 - val_accuracy: 0.9912
Epoch 41/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0030 -
accuracy: 0.9983 - val_loss: 0.0097 - val_accuracy: 0.9920
Epoch 42/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0027 -
accuracy: 0.9985 - val_loss: 0.0109 - val_accuracy: 0.9909
Epoch 43/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0029 -
accuracy: 0.9985 - val_loss: 0.0103 - val_accuracy: 0.9910
Epoch 44/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0027 -
accuracy: 0.9989 - val_loss: 0.0100 - val_accuracy: 0.9909
Epoch 45/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0029 -
accuracy: 0.9987 - val_loss: 0.0114 - val_accuracy: 0.9912
Epoch 46/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0026 -
accuracy: 0.9985 - val_loss: 0.0111 - val_accuracy: 0.9905
```

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Epoch 47/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0026 -
accuracy: 0.9990 - val_loss: 0.0098 - val_accuracy: 0.9921
Epoch 48/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0028 -
accuracy: 0.9986 - val_loss: 0.0107 - val_accuracy: 0.9918
Epoch 49/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0024 -
accuracy: 0.9990 - val_loss: 0.0105 - val_accuracy: 0.9910
Epoch 50/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0026 -
accuracy: 0.9990 - val_loss: 0.0111 - val_accuracy: 0.9913
Epoch 51/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0032 -
accuracy: 0.9985 - val_loss: 0.0099 - val_accuracy: 0.9925
Epoch 52/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0024 -
accuracy: 0.9987 - val_loss: 0.0126 - val_accuracy: 0.9911
Epoch 53/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0025 -
accuracy: 0.9988 - val_loss: 0.0108 - val_accuracy: 0.9912
Epoch 54/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0028 -
accuracy: 0.9987 - val_loss: 0.0105 - val_accuracy: 0.9912
Epoch 55/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0024 -
accuracy: 0.9989 - val_loss: 0.0107 - val_accuracy: 0.9923
Epoch 56/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0021 -
accuracy: 0.9991 - val_loss: 0.0105 - val_accuracy: 0.9914
Epoch 57/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0024 -
accuracy: 0.9990 - val_loss: 0.0117 - val_accuracy: 0.9908
Epoch 58/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0023 -
accuracy: 0.9990 - val_loss: 0.0112 - val_accuracy: 0.9912
Epoch 59/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0023 -
accuracy: 0.9991 - val_loss: 0.0108 - val_accuracy: 0.9913
Epoch 60/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0020 -
accuracy: 0.9988 - val_loss: 0.0113 - val_accuracy: 0.9915
Epoch 61/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0022 -
accuracy: 0.9990 - val_loss: 0.0100 - val_accuracy: 0.9916
Epoch 62/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0021 -
accuracy: 0.9992 - val_loss: 0.0122 - val_accuracy: 0.9902
```

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Epoch 63/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9991 - val_loss: 0.0115 - val_accuracy: 0.9912
Epoch 64/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9992 - val_loss: 0.0111 - val_accuracy: 0.9924
Epoch 65/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0023 -
accuracy: 0.9991 - val_loss: 0.0115 - val_accuracy: 0.9912
Epoch 66/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0020 -
accuracy: 0.9994 - val_loss: 0.0108 - val_accuracy: 0.9918
Epoch 67/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9993 - val_loss: 0.0109 - val_accuracy: 0.9916
Epoch 68/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9990 - val_loss: 0.0112 - val_accuracy: 0.9910
Epoch 69/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0022 -
accuracy: 0.9987 - val_loss: 0.0123 - val_accuracy: 0.9912
Epoch 70/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9993 - val_loss: 0.0111 - val_accuracy: 0.9915
Epoch 71/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0016 -
accuracy: 0.9993 - val_loss: 0.0140 - val_accuracy: 0.9909
Epoch 72/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0023 -
accuracy: 0.9992 - val_loss: 0.0111 - val_accuracy: 0.9916
Epoch 73/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0015 -
accuracy: 0.9993 - val_loss: 0.0128 - val_accuracy: 0.9908
Epoch 74/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0021 -
accuracy: 0.9993 - val_loss: 0.0122 - val_accuracy: 0.9918
Epoch 75/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0018 -
accuracy: 0.9994 - val_loss: 0.0114 - val_accuracy: 0.9915
Epoch 76/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0019 -
accuracy: 0.9995 - val_loss: 0.0111 - val_accuracy: 0.9915
Epoch 77/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0018 -
accuracy: 0.9994 - val_loss: 0.0108 - val_accuracy: 0.9926
Epoch 78/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0019 -
accuracy: 0.9994 - val_loss: 0.0134 - val_accuracy: 0.9903
```

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Epoch 79/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0019 -
accuracy: 0.9993 - val_loss: 0.0122 - val_accuracy: 0.9920
Epoch 80/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0017 -
accuracy: 0.9993 - val_loss: 0.0124 - val_accuracy: 0.9916
Epoch 81/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0015 -
accuracy: 0.9996 - val_loss: 0.0125 - val_accuracy: 0.9906
Epoch 82/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0019 -
accuracy: 0.9993 - val_loss: 0.0111 - val_accuracy: 0.9912
Epoch 83/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0018 -
accuracy: 0.9992 - val_loss: 0.0133 - val_accuracy: 0.9918
Epoch 84/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9996 - val_loss: 0.0123 - val_accuracy: 0.9912
Epoch 85/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0016 -
accuracy: 0.9992 - val_loss: 0.0144 - val_accuracy: 0.9908
Epoch 86/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0018 -
accuracy: 0.9993 - val_loss: 0.0143 - val_accuracy: 0.9912
Epoch 87/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0017 -
accuracy: 0.9994 - val_loss: 0.0132 - val_accuracy: 0.9902
Epoch 88/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0019 -
accuracy: 0.9993 - val_loss: 0.0117 - val_accuracy: 0.9913
Epoch 89/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0020 -
accuracy: 0.9992 - val_loss: 0.0129 - val_accuracy: 0.9915
Epoch 90/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0020 -
accuracy: 0.9994 - val_loss: 0.0123 - val_accuracy: 0.9909
Epoch 91/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0018 -
accuracy: 0.9993 - val_loss: 0.0127 - val_accuracy: 0.9922
Epoch 92/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0014 -
accuracy: 0.9994 - val_loss: 0.0125 - val_accuracy: 0.9920
Epoch 93/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0021 -
accuracy: 0.9993 - val_loss: 0.0115 - val_accuracy: 0.9920
Epoch 94/100
375/375 [==============================] - 13s 36ms/step - loss: 0.0015 -
accuracy: 0.9996 - val_loss: 0.0121 - val_accuracy: 0.9916
```

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Epoch 95/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0017 -
accuracy: 0.9993 - val_loss: 0.0129 - val_accuracy: 0.9912
Epoch 96/100
375/375 [==============================] - 14s 36ms/step - loss: 0.0015 -
accuracy: 0.9996 - val_loss: 0.0133 - val_accuracy: 0.9908
Epoch 97/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0015 -
accuracy: 0.9996 - val_loss: 0.0135 - val_accuracy: 0.9916
Epoch 98/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0014 -
accuracy: 0.9994 - val_loss: 0.0119 - val_accuracy: 0.9922
Epoch 99/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0015 -
accuracy: 0.9995 - val_loss: 0.0140 - val_accuracy: 0.9921
Epoch 100/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0022 -
accuracy: 0.9991 - val_loss: 0.0120 - val_accuracy: 0.9914

Training with -->selu<-- activation function

Epoch 1/100
375/375 [==============================] - 15s 39ms/step - loss: 0.1545 -
accuracy: 0.7406 - val_loss: 0.0338 - val_accuracy: 0.9716
Epoch 2/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0331 -
accuracy: 0.9557 - val_loss: 0.0241 - val_accuracy: 0.9822
Epoch 3/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0235 -
accuracy: 0.9697 - val_loss: 0.0242 - val_accuracy: 0.9843
Epoch 4/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0196 -
accuracy: 0.9739 - val_loss: 0.0234 - val_accuracy: 0.9860
Epoch 5/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0182 -
accuracy: 0.9767 - val_loss: 0.0212 - val_accuracy: 0.9876
Epoch 6/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0161 -
accuracy: 0.9794 - val_loss: 0.0229 - val_accuracy: 0.9875
Epoch 7/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0140 -
accuracy: 0.9832 - val_loss: 0.0192 - val_accuracy: 0.9882
Epoch 8/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0134 -
accuracy: 0.9834 - val_loss: 0.0216 - val_accuracy: 0.9875
Epoch 9/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0126 -
accuracy: 0.9841 - val_loss: 0.0250 - val_accuracy: 0.9868
```

```
Epoch 10/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0124 -
accuracy: 0.9852 - val_loss: 0.0255 - val_accuracy: 0.9886
Epoch 11/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0115 -
accuracy: 0.9856 - val_loss: 0.0230 - val_accuracy: 0.9886
Epoch 12/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0104 -
accuracy: 0.9872 - val_loss: 0.0212 - val_accuracy: 0.9886
Epoch 13/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0103 -
accuracy: 0.9871 - val_loss: 0.0245 - val_accuracy: 0.9891
Epoch 14/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0101 -
accuracy: 0.9874 - val_loss: 0.0261 - val_accuracy: 0.9884
Epoch 15/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0095 -
accuracy: 0.9876 - val_loss: 0.0211 - val_accuracy: 0.9899
Epoch 16/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0094 -
accuracy: 0.9885 - val_loss: 0.0267 - val_accuracy: 0.9883
Epoch 17/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0095 -
accuracy: 0.9870 - val_loss: 0.0252 - val_accuracy: 0.9891
Epoch 18/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0089 -
accuracy: 0.9884 - val_loss: 0.0275 - val_accuracy: 0.9893
Epoch 19/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0088 -
accuracy: 0.9888 - val_loss: 0.0248 - val_accuracy: 0.9899
Epoch 20/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0084 -
accuracy: 0.9888 - val_loss: 0.0264 - val_accuracy: 0.9898
Epoch 21/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0076 -
accuracy: 0.9915 - val_loss: 0.0267 - val_accuracy: 0.9895
Epoch 22/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0077 -
accuracy: 0.9901 - val_loss: 0.0273 - val_accuracy: 0.9899
Epoch 23/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0079 -
accuracy: 0.9912 - val_loss: 0.0278 - val_accuracy: 0.9900
Epoch 24/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0077 -
accuracy: 0.9903 - val_loss: 0.0284 - val_accuracy: 0.9893
Epoch 25/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0073 -
accuracy: 0.9917 - val_loss: 0.0279 - val_accuracy: 0.9893
```

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Epoch 26/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0068 -
accuracy: 0.9920 - val_loss: 0.0309 - val_accuracy: 0.9902
Epoch 27/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0069 -
accuracy: 0.9915 - val_loss: 0.0291 - val_accuracy: 0.9899
Epoch 28/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0069 -
accuracy: 0.9909 - val_loss: 0.0315 - val_accuracy: 0.9883
Epoch 29/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0067 -
accuracy: 0.9922 - val_loss: 0.0304 - val_accuracy: 0.9885
Epoch 30/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0059 -
accuracy: 0.9938 - val_loss: 0.0297 - val_accuracy: 0.9898
Epoch 31/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0070 -
accuracy: 0.9915 - val_loss: 0.0323 - val_accuracy: 0.9888
Epoch 32/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0066 -
accuracy: 0.9923 - val_loss: 0.0306 - val_accuracy: 0.9888
Epoch 33/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0066 -
accuracy: 0.9928 - val_loss: 0.0310 - val_accuracy: 0.9893
Epoch 34/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0065 -
accuracy: 0.9924 - val_loss: 0.0310 - val_accuracy: 0.9895
Epoch 35/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0061 -
accuracy: 0.9923 - val_loss: 0.0342 - val_accuracy: 0.9889
Epoch 36/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0064 -
accuracy: 0.9927 - val_loss: 0.0323 - val_accuracy: 0.9898
Epoch 37/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0069 -
accuracy: 0.9915 - val_loss: 0.0326 - val_accuracy: 0.9892
Epoch 38/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0058 -
accuracy: 0.9936 - val_loss: 0.0385 - val_accuracy: 0.9899
Epoch 39/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0055 -
accuracy: 0.9938 - val_loss: 0.0340 - val_accuracy: 0.9895
Epoch 40/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0056 -
accuracy: 0.9936 - val_loss: 0.0378 - val_accuracy: 0.9900
Epoch 41/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0053 -
accuracy: 0.9936 - val_loss: 0.0345 - val_accuracy: 0.9893
```

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Epoch 42/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0059 -
accuracy: 0.9933 - val_loss: 0.0370 - val_accuracy: 0.9894
Epoch 43/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0051 -
accuracy: 0.9945 - val_loss: 0.0346 - val_accuracy: 0.9884
Epoch 44/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0055 -
accuracy: 0.9933 - val_loss: 0.0373 - val_accuracy: 0.9899
Epoch 45/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0052 -
accuracy: 0.9939 - val_loss: 0.0394 - val_accuracy: 0.9892
Epoch 46/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0053 -
accuracy: 0.9934 - val_loss: 0.0324 - val_accuracy: 0.9893
Epoch 47/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0050 -
accuracy: 0.9944 - val_loss: 0.0431 - val_accuracy: 0.9883
Epoch 48/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0048 -
accuracy: 0.9948 - val_loss: 0.0409 - val_accuracy: 0.9902
Epoch 49/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0055 -
accuracy: 0.9938 - val_loss: 0.0436 - val_accuracy: 0.9887
Epoch 50/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0052 -
accuracy: 0.9940 - val_loss: 0.0405 - val_accuracy: 0.9898
Epoch 51/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0049 -
accuracy: 0.9943 - val_loss: 0.0435 - val_accuracy: 0.9893
Epoch 52/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0050 -
accuracy: 0.9946 - val_loss: 0.0390 - val_accuracy: 0.9903
Epoch 53/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0052 -
accuracy: 0.9939 - val_loss: 0.0372 - val_accuracy: 0.9899
Epoch 54/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0048 -
accuracy: 0.9946 - val_loss: 0.0354 - val_accuracy: 0.9892
Epoch 55/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0045 -
accuracy: 0.9947 - val_loss: 0.0365 - val_accuracy: 0.9904
Epoch 56/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0050 -
accuracy: 0.9946 - val_loss: 0.0449 - val_accuracy: 0.9887
Epoch 57/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0048 -
accuracy: 0.9944 - val_loss: 0.0348 - val_accuracy: 0.9896
```

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Epoch 58/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0050 -
accuracy: 0.9943 - val_loss: 0.0416 - val_accuracy: 0.9895
Epoch 59/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0039 -
accuracy: 0.9960 - val_loss: 0.0383 - val_accuracy: 0.9897
Epoch 60/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0051 -
accuracy: 0.9946 - val_loss: 0.0387 - val_accuracy: 0.9897
Epoch 61/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0044 -
accuracy: 0.9948 - val_loss: 0.0397 - val_accuracy: 0.9908
Epoch 62/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0052 -
accuracy: 0.9946 - val_loss: 0.0435 - val_accuracy: 0.9892
Epoch 63/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0044 -
accuracy: 0.9951 - val_loss: 0.0429 - val_accuracy: 0.9897
Epoch 64/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0046 -
accuracy: 0.9944 - val_loss: 0.0452 - val_accuracy: 0.9888
Epoch 65/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0051 -
accuracy: 0.9945 - val_loss: 0.0468 - val_accuracy: 0.9901
Epoch 66/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0047 -
accuracy: 0.9941 - val_loss: 0.0459 - val_accuracy: 0.9900
Epoch 67/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0048 -
accuracy: 0.9948 - val_loss: 0.0445 - val_accuracy: 0.9905
Epoch 68/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0046 -
accuracy: 0.9948 - val_loss: 0.0387 - val_accuracy: 0.9900
Epoch 69/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0041 -
accuracy: 0.9951 - val_loss: 0.0406 - val_accuracy: 0.9904
Epoch 70/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0043 -
accuracy: 0.9953 - val_loss: 0.0454 - val_accuracy: 0.9903
Epoch 71/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0042 -
accuracy: 0.9954 - val_loss: 0.0461 - val_accuracy: 0.9889
Epoch 72/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0044 -
accuracy: 0.9953 - val_loss: 0.0435 - val_accuracy: 0.9907
Epoch 73/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0041 -
accuracy: 0.9956 - val_loss: 0.0465 - val_accuracy: 0.9904
```

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Epoch 74/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0047 -
accuracy: 0.9944 - val_loss: 0.0428 - val_accuracy: 0.9890
Epoch 75/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0042 -
accuracy: 0.9951 - val_loss: 0.0483 - val_accuracy: 0.9903
Epoch 76/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0038 -
accuracy: 0.9964 - val_loss: 0.0441 - val_accuracy: 0.9895
Epoch 77/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0040 -
accuracy: 0.9954 - val_loss: 0.0433 - val_accuracy: 0.9902
Epoch 78/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0038 -
accuracy: 0.9950 - val_loss: 0.0440 - val_accuracy: 0.9898
Epoch 79/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0040 -
accuracy: 0.9956 - val_loss: 0.0432 - val_accuracy: 0.9896
Epoch 80/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0041 -
accuracy: 0.9960 - val_loss: 0.0437 - val_accuracy: 0.9906
Epoch 81/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0040 -
accuracy: 0.9957 - val_loss: 0.0478 - val_accuracy: 0.9894
Epoch 82/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0041 -
accuracy: 0.9955 - val_loss: 0.0486 - val_accuracy: 0.9895
Epoch 83/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0041 -
accuracy: 0.9957 - val_loss: 0.0568 - val_accuracy: 0.9877
Epoch 84/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0046 -
accuracy: 0.9953 - val_loss: 0.0479 - val_accuracy: 0.9894
Epoch 85/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0040 -
accuracy: 0.9964 - val_loss: 0.0522 - val_accuracy: 0.9890
Epoch 86/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0045 -
accuracy: 0.9951 - val_loss: 0.0480 - val_accuracy: 0.9903
Epoch 87/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0038 -
accuracy: 0.9956 - val_loss: 0.0459 - val_accuracy: 0.9899
Epoch 88/100
375/375 [==============================] - 15s 40ms/step - loss: 0.0038 -
accuracy: 0.9957 - val_loss: 0.0482 - val_accuracy: 0.9890
Epoch 89/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0040 -
accuracy: 0.9957 - val_loss: 0.0514 - val_accuracy: 0.9902
```

```
Epoch 90/100
375/375 [==============================] - 14s 39ms/step - loss: 0.0038 -
accuracy: 0.9962 - val_loss: 0.0502 - val_accuracy: 0.9893
Epoch 91/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0039 -
accuracy: 0.9960 - val_loss: 0.0494 - val_accuracy: 0.9900
Epoch 92/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0038 -
accuracy: 0.9960 - val_loss: 0.0506 - val_accuracy: 0.9898
Epoch 93/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0039 -
accuracy: 0.9954 - val_loss: 0.0560 - val_accuracy: 0.9894
Epoch 94/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0044 -
accuracy: 0.9958 - val_loss: 0.0483 - val_accuracy: 0.9902
Epoch 95/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0047 -
accuracy: 0.9951 - val_loss: 0.0475 - val_accuracy: 0.9902
Epoch 96/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0036 -
accuracy: 0.9956 - val_loss: 0.0529 - val_accuracy: 0.9898
Epoch 97/100
375/375 [==============================] - 14s 37ms/step - loss: 0.0038 -
accuracy: 0.9958 - val_loss: 0.0509 - val_accuracy: 0.9900
Epoch 98/100
375/375 [==============================] - 14s 38ms/step - loss: 0.0040 -
accuracy: 0.9967 - val_loss: 0.0510 - val_accuracy: 0.9901
Epoch 99/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0039 -
accuracy: 0.9966 - val_loss: 0.0453 - val_accuracy: 0.9898
Epoch 100/100
375/375 [==============================] - 15s 39ms/step - loss: 0.0032 -
accuracy: 0.9965 - val_loss: 0.0582 - val_accuracy: 0.9899

Training with -->gelu<-- activation function

Epoch 1/100
375/375 [==============================] - 24s 64ms/step - loss: 0.1684 -
accuracy: 0.7077 - val_loss: 0.0162 - val_accuracy: 0.9778
Epoch 2/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0247 -
accuracy: 0.9687 - val_loss: 0.0109 - val_accuracy: 0.9843
Epoch 3/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0171 -
accuracy: 0.9782 - val_loss: 0.0094 - val_accuracy: 0.9863
Epoch 4/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0138 -
accuracy: 0.9823 - val_loss: 0.0089 - val_accuracy: 0.9875
```

```
Epoch 5/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0117 -
accuracy: 0.9855 - val_loss: 0.0080 - val_accuracy: 0.9879
Epoch 6/100
375/375 [==============================] - 23s 63ms/step - loss: 0.0095 -
accuracy: 0.9888 - val_loss: 0.0082 - val_accuracy: 0.9884
Epoch 7/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0085 -
accuracy: 0.9896 - val_loss: 0.0082 - val_accuracy: 0.9878
Epoch 8/100
375/375 [==============================] - 24s 65ms/step - loss: 0.0075 -
accuracy: 0.9916 - val_loss: 0.0078 - val_accuracy: 0.9898
Epoch 9/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0069 -
accuracy: 0.9918 - val_loss: 0.0080 - val_accuracy: 0.9901
Epoch 10/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0067 -
accuracy: 0.9923 - val_loss: 0.0079 - val_accuracy: 0.9888
Epoch 11/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0054 -
accuracy: 0.9945 - val_loss: 0.0074 - val_accuracy: 0.9902
Epoch 12/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0059 -
accuracy: 0.9931 - val_loss: 0.0082 - val_accuracy: 0.9895
Epoch 13/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0051 -
accuracy: 0.9938 - val_loss: 0.0077 - val_accuracy: 0.9902
Epoch 14/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0048 -
accuracy: 0.9946 - val_loss: 0.0080 - val_accuracy: 0.9902
Epoch 15/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0045 -
accuracy: 0.9945 - val_loss: 0.0079 - val_accuracy: 0.9906
Epoch 16/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0039 -
accuracy: 0.9963 - val_loss: 0.0083 - val_accuracy: 0.9903
Epoch 17/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0041 -
accuracy: 0.9955 - val_loss: 0.0082 - val_accuracy: 0.9910
Epoch 18/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0040 -
accuracy: 0.9955 - val_loss: 0.0088 - val_accuracy: 0.9912
Epoch 19/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0039 -
accuracy: 0.9960 - val_loss: 0.0084 - val_accuracy: 0.9910
Epoch 20/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0033 -
accuracy: 0.9966 - val_loss: 0.0085 - val_accuracy: 0.9911
```

```
Epoch 21/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0034 -
accuracy: 0.9966 - val_loss: 0.0076 - val_accuracy: 0.9918
Epoch 22/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0037 -
accuracy: 0.9963 - val_loss: 0.0083 - val_accuracy: 0.9923
Epoch 23/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0032 -
accuracy: 0.9969 - val_loss: 0.0082 - val_accuracy: 0.9916
Epoch 24/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0032 -
accuracy: 0.9970 - val_loss: 0.0089 - val_accuracy: 0.9912
Epoch 25/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0027 -
accuracy: 0.9971 - val_loss: 0.0091 - val_accuracy: 0.9912
Epoch 26/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0029 -
accuracy: 0.9971 - val_loss: 0.0093 - val_accuracy: 0.9918
Epoch 27/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0025 -
accuracy: 0.9974 - val_loss: 0.0095 - val_accuracy: 0.9908
Epoch 28/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0028 -
accuracy: 0.9972 - val_loss: 0.0095 - val_accuracy: 0.9922
Epoch 29/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0027 -
accuracy: 0.9977 - val_loss: 0.0086 - val_accuracy: 0.9920
Epoch 30/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0025 -
accuracy: 0.9979 - val_loss: 0.0090 - val_accuracy: 0.9911
Epoch 31/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0023 -
accuracy: 0.9980 - val_loss: 0.0090 - val_accuracy: 0.9917
Epoch 32/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0023 -
accuracy: 0.9982 - val_loss: 0.0088 - val_accuracy: 0.9915
Epoch 33/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0023 -
accuracy: 0.9976 - val_loss: 0.0099 - val_accuracy: 0.9915
Epoch 34/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0021 -
accuracy: 0.9983 - val_loss: 0.0092 - val_accuracy: 0.9917
Epoch 35/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0026 -
accuracy: 0.9975 - val_loss: 0.0096 - val_accuracy: 0.9916
Epoch 36/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0021 -
accuracy: 0.9985 - val_loss: 0.0091 - val_accuracy: 0.9922
```

```
Epoch 37/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0020 -
accuracy: 0.9985 - val_loss: 0.0094 - val_accuracy: 0.9931
Epoch 38/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0019 -
accuracy: 0.9978 - val_loss: 0.0088 - val_accuracy: 0.9918
Epoch 39/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0023 -
accuracy: 0.9981 - val_loss: 0.0099 - val_accuracy: 0.9933
Epoch 40/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0019 -
accuracy: 0.9985 - val_loss: 0.0098 - val_accuracy: 0.9919
Epoch 41/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0021 -
accuracy: 0.9977 - val_loss: 0.0107 - val_accuracy: 0.9919
Epoch 42/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0018 -
accuracy: 0.9984 - val_loss: 0.0103 - val_accuracy: 0.9917
Epoch 43/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0018 -
accuracy: 0.9983 - val_loss: 0.0095 - val_accuracy: 0.9918
Epoch 44/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0016 -
accuracy: 0.9982 - val_loss: 0.0106 - val_accuracy: 0.9914
Epoch 48/100
375/375 [==============================] - 23s 63ms/step - loss: 0.0015 -
accuracy: 0.9990 - val_loss: 0.0105 - val_accuracy: 0.9911
Epoch 49/100
375/375 [==============================] - 23s 63ms/step - loss: 0.0018 -
accuracy: 0.9984 - val_loss: 0.0092 - val_accuracy: 0.9921
Epoch 50/100
375/375 [==============================] - 23s 63ms/step - loss: 0.0015 -
accuracy: 0.9987 - val_loss: 0.0106 - val_accuracy: 0.9911
Epoch 51/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0017 -
accuracy: 0.9987 - val_loss: 0.0105 - val_accuracy: 0.9917
Epoch 52/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0017 -
accuracy: 0.9988 - val_loss: 0.0096 - val_accuracy: 0.9917
Epoch 53/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0017 -
accuracy: 0.9985 - val_loss: 0.0111 - val_accuracy: 0.9908
Epoch 57/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0016 -
accuracy: 0.9988 - val_loss: 0.0129 - val_accuracy: 0.9923
Epoch 58/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0014 -
accuracy: 0.9988 - val_loss: 0.0113 - val_accuracy: 0.9915
```

```
Epoch 59/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0015 -
accuracy: 0.9990 - val_loss: 0.0111 - val_accuracy: 0.9921
Epoch 60/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0017 -
accuracy: 0.9986 - val_loss: 0.0116 - val_accuracy: 0.9916
Epoch 61/100
375/375 [==============================] - 23s 63ms/step - loss: 0.0014 -
accuracy: 0.9989 - val_loss: 0.0124 - val_accuracy: 0.9914
Epoch 62/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0014 -
accuracy: 0.9987 - val_loss: 0.0123 - val_accuracy: 0.9916
Epoch 63/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0015 -
accuracy: 0.9989 - val_loss: 0.0104 - val_accuracy: 0.9919
Epoch 64/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0017 -
accuracy: 0.9985 - val_loss: 0.0102 - val_accuracy: 0.9920
Epoch 65/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0011 -
accuracy: 0.9993 - val_loss: 0.0105 - val_accuracy: 0.9919
Epoch 69/100
375/375 [==============================] - 23s 62ms/step - loss: 0.0014 -
accuracy: 0.9987 - val_loss: 0.0125 - val_accuracy: 0.9921
Epoch 70/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0017 -
accuracy: 0.9985 - val_loss: 0.0122 - val_accuracy: 0.9914
Epoch 71/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0014 -
accuracy: 0.9988 - val_loss: 0.0111 - val_accuracy: 0.9918
Epoch 72/100
375/375 [==============================] - 25s 66ms/step - loss: 0.0013 -
accuracy: 0.9990 - val_loss: 0.0114 - val_accuracy: 0.9925
Epoch 73/100
375/375 [==============================] - 25s 66ms/step - loss: 0.0012 -
accuracy: 0.9990 - val_loss: 0.0113 - val_accuracy: 0.9918
Epoch 74/100
375/375 [==============================] - 25s 65ms/step - loss: 0.0013 -
accuracy: 0.9987 - val_loss: 0.0107 - val_accuracy: 0.9923
Epoch 75/100
375/375 [==============================] - 25s 65ms/step - loss: 0.0012 -
accuracy: 0.9989 - val_loss: 0.0122 - val_accuracy: 0.9916
Epoch 76/100
375/375 [==============================] - 24s 65ms/step - loss: 0.0013 -
accuracy: 0.9991 - val_loss: 0.0124 - val_accuracy: 0.9918
Epoch 77/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0013 -
accuracy: 0.9989 - val_loss: 0.0102 - val_accuracy: 0.9913
```

```
Epoch 78/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0012 -
accuracy: 0.9992 - val_loss: 0.0124 - val_accuracy: 0.9912
Epoch 79/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0014 -
accuracy: 0.9988 - val_loss: 0.0117 - val_accuracy: 0.9924
Epoch 80/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0013 -
accuracy: 0.9989 - val_loss: 0.0117 - val_accuracy: 0.9916
Epoch 81/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0013 -
accuracy: 0.9989 - val_loss: 0.0134 - val_accuracy: 0.9919
Epoch 82/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0012 -
accuracy: 0.9989 - val_loss: 0.0122 - val_accuracy: 0.9919
Epoch 86/100
375/375 [==============================] - 24s 63ms/step - loss: 0.0011 -
accuracy: 0.9992 - val_loss: 0.0112 - val_accuracy: 0.9915
Epoch 87/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0013 -
accuracy: 0.9988 - val_loss: 0.0127 - val_accuracy: 0.9922
Epoch 88/100
375/375 [==============================] - 24s 63ms/step - loss: 9.9249e-04 -
accuracy: 0.9994 - val_loss: 0.0127 - val_accuracy: 0.9916
Epoch 89/100
375/375 [==============================] - 24s 64ms/step - loss: 9.7712e-04 -
accuracy: 0.9993 - val_loss: 0.0149 - val_accuracy: 0.9920
Epoch 90/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0010 -
accuracy: 0.9991 - val_loss: 0.0122 - val_accuracy: 0.9920
Epoch 91/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0011 -
accuracy: 0.9990 - val_loss: 0.0123 - val_accuracy: 0.9927
Epoch 92/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0013 -
accuracy: 0.9991 - val_loss: 0.0131 - val_accuracy: 0.9923
Epoch 93/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0012 -
accuracy: 0.9991 - val_loss: 0.0141 - val_accuracy: 0.9918
Epoch 94/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0010 -
accuracy: 0.9993 - val_loss: 0.0130 - val_accuracy: 0.9915
Epoch 95/100
375/375 [==============================] - 24s 65ms/step - loss: 8.7709e-04 -
accuracy: 0.9993 - val_loss: 0.0132 - val_accuracy: 0.9923
Epoch 96/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0015 -
accuracy: 0.9986 - val_loss: 0.0126 - val_accuracy: 0.9921
```

```
Epoch 97/100
375/375 [==============================] - 24s 64ms/step - loss: 9.9341e-04 -
accuracy: 0.9994 - val_loss: 0.0135 - val_accuracy: 0.9913
Epoch 98/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0011 -
accuracy: 0.9995 - val_loss: 0.0133 - val_accuracy: 0.9923
Epoch 99/100
375/375 [==============================] - 24s 64ms/step - loss: 0.0011 -
accuracy: 0.9990 - val_loss: 0.0120 - val_accuracy: 0.9915
Epoch 100/100
375/375 [==============================] - 24s 65ms/step - loss: 0.0011 -
accuracy: 0.9992 - val_loss: 0.0137 - val_accuracy: 0.9918
[<tensorflow.python.keras.callbacks.History object at 0x7fe3e1b02730>,
<tensorflow.python.keras.callbacks.History object at 0x7fe3cc77a610>,
<tensorflow.python.keras.callbacks.History object at 0x7fe3e18e40a0>,
<tensorflow.python.keras.callbacks.History object at 0x7fe3cc4e8f70>,
<tensorflow.python.keras.callbacks.History object at 0x7fe3cc309400>,
<tensorflow.python.keras.callbacks.History object at 0x7fe3cc1422e0>]
```

[12]:
```
for act_func_item in result:
    for prop in act_func_item.history:
        print(prop)
```

```
loss
accuracy
val_loss
val_accuracy
loss
accuracy
val_loss
val_accuracy
loss
accuracy
val_loss
val_accuracy
loss
accuracy
val_loss
val_accuracy
loss
accuracy
val_loss
val_accuracy
loss
accuracy
val_loss
val_accuracy
```

5 4. Graph the results

[13]:
```
def plot_act_func_results(results, activation_functions = []):
    plt.figure(figsize=(10,10))
    plt.style.use('dark_background')

    # Plot validation accuracy values
    for act_func in results:
        plt.plot(act_func.history['val_accuracy'])

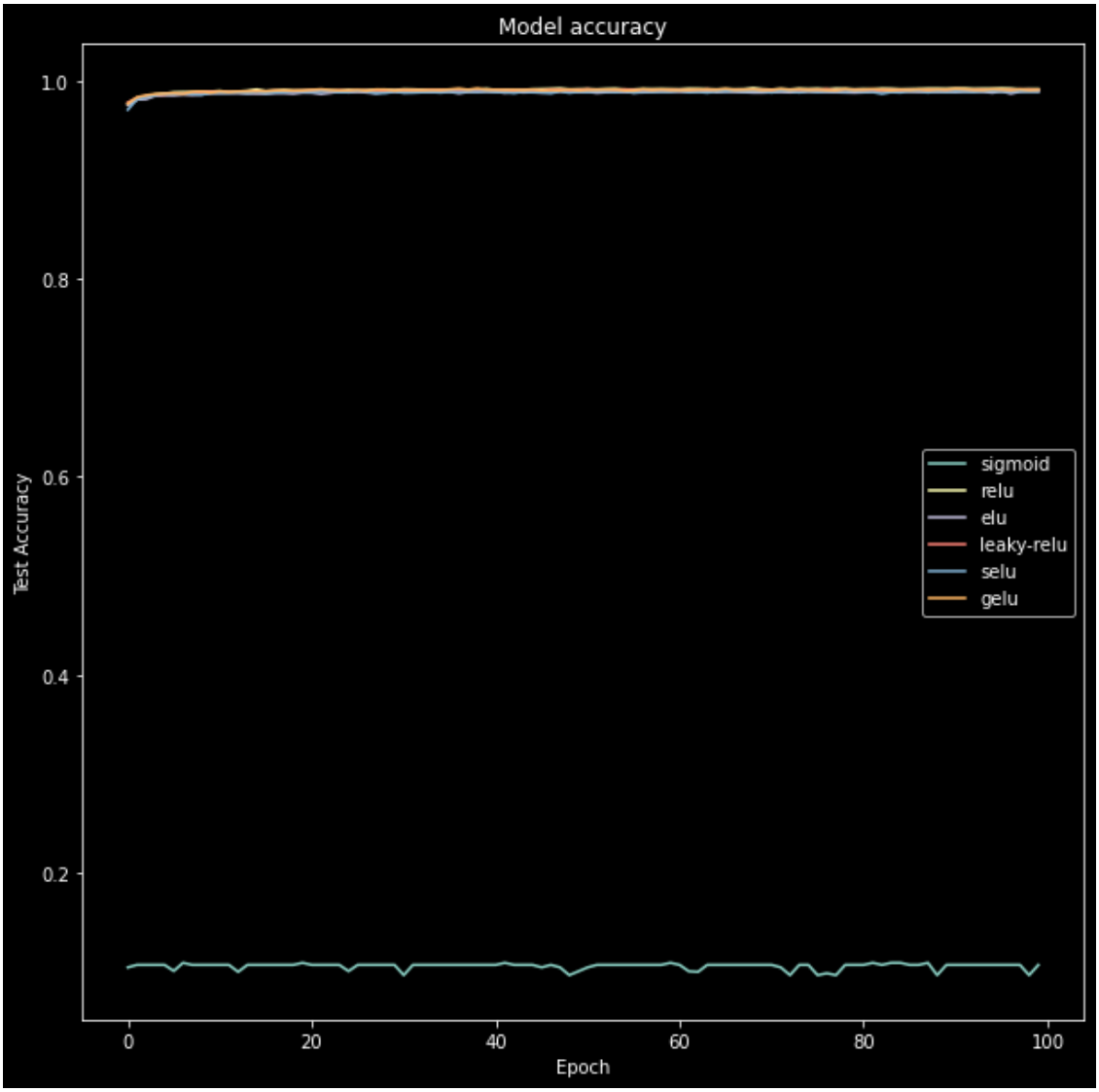
    plt.title('Model accuracy')
    plt.ylabel('Test Accuracy')
    plt.xlabel('Epoch')
    plt.legend(activation_functions)
    plt.show()

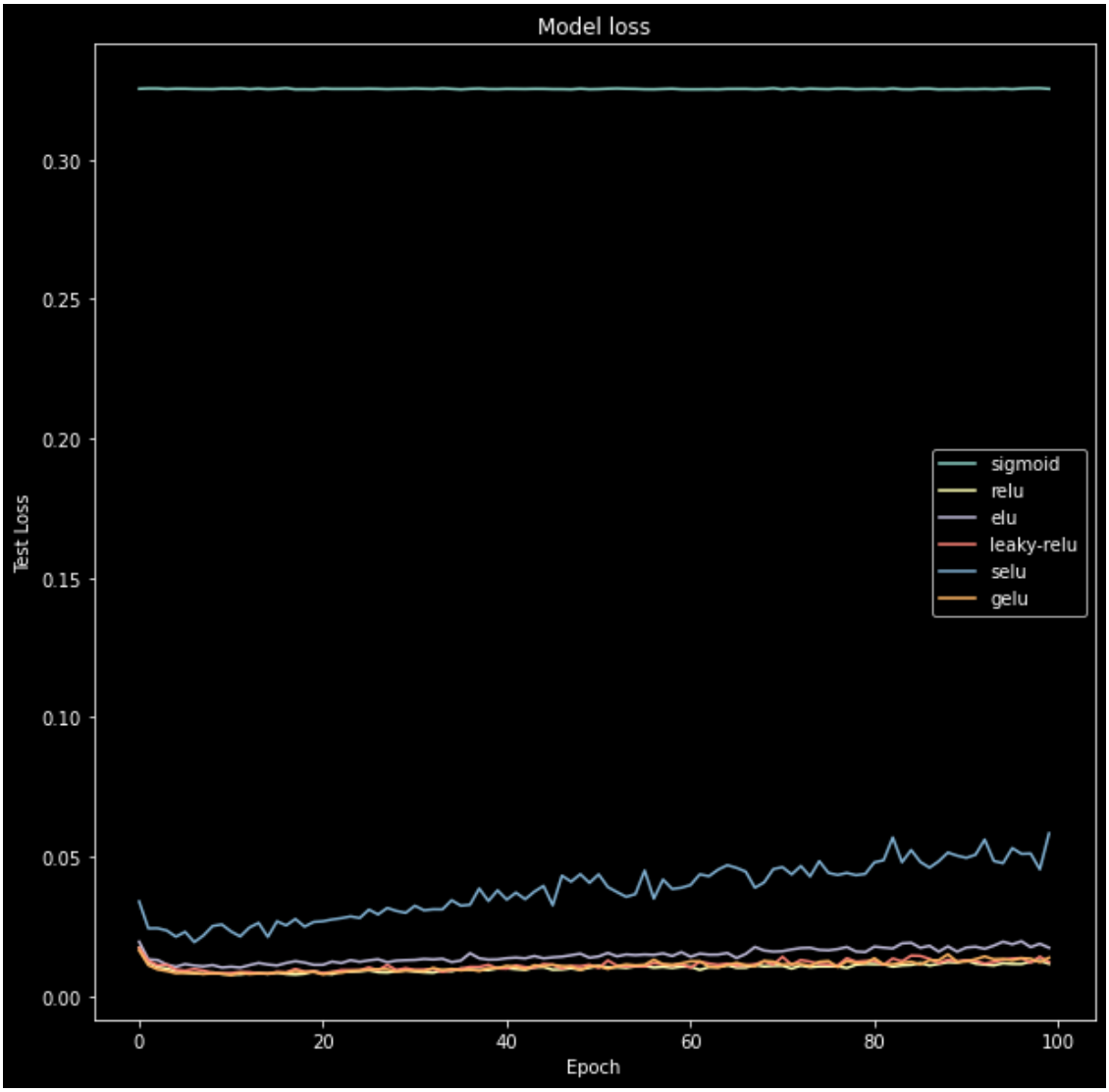
    # Plot validation loss values
    plt.figure(figsize=(10,10))

    for act_func in results:
        plt.plot(act_func.history['val_loss'])

    plt.title('Model loss')
    plt.ylabel('Test Loss')
    plt.xlabel('Epoch')
    plt.legend(activation_functions)
    plt.show()

plot_act_func_results(result, act_func)
```


Model accuracy
Test Accuracy
Epoch
1.0
0.8
0.6
0.4
0.2
0
20
40
60
80
100
sigmoid
relu
elu
leaky-relu
selu
gelu



[14]:
```
new_act_arr = act_func[1:]
new_results = result[1:]

def plot_act_func_results(results, activation_functions = []):
    plt.figure(figsize=(10,10))
    plt.style.use('dark_background')

    # Plot validation accuracy values
    for act_func in results:
        plt.plot(act_func.history['val_accuracy'])

    plt.title('Model accuracy')
    plt.ylabel('Test Accuracy')
```

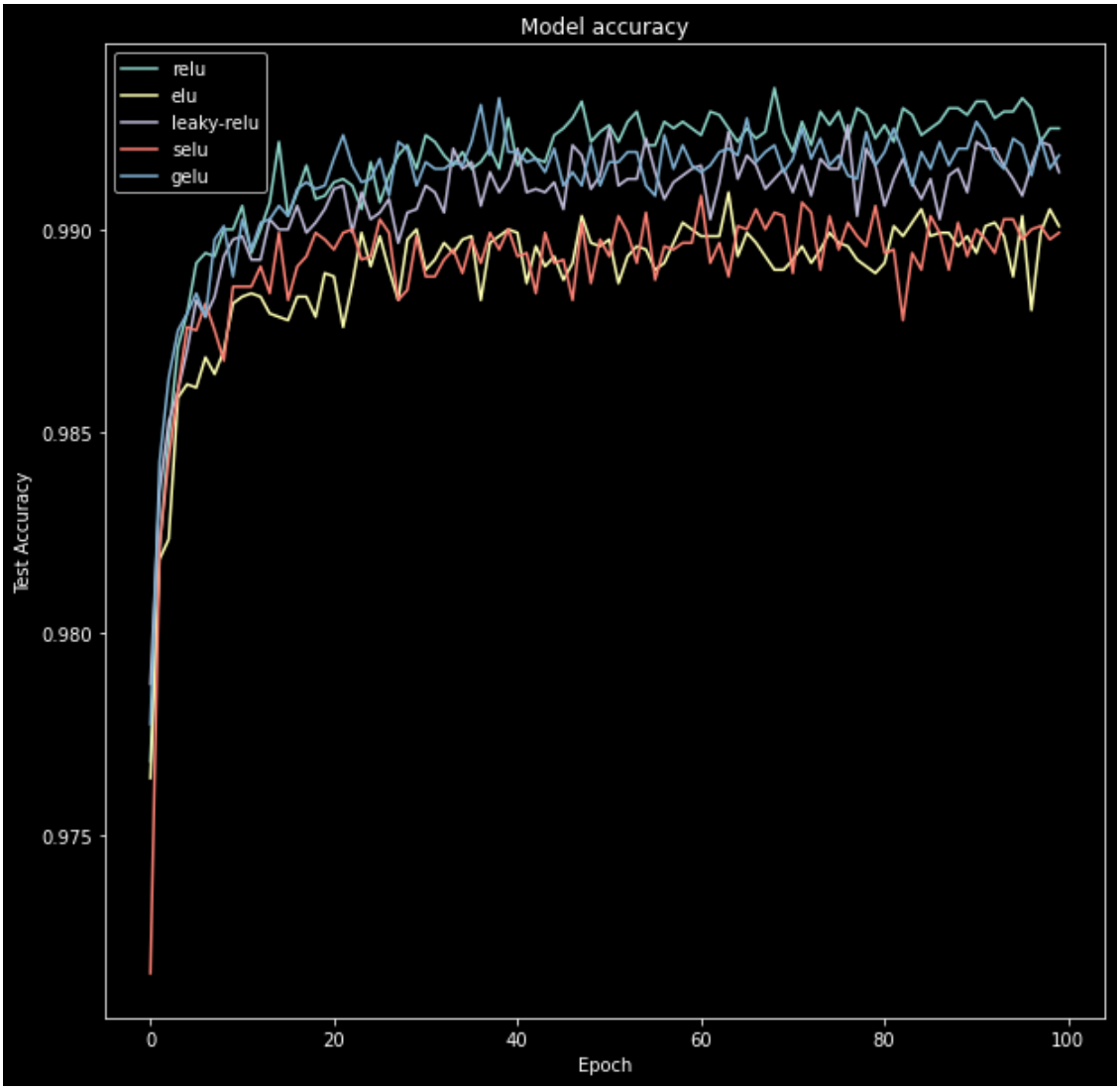
```
    plt.xlabel('Epoch')
    plt.legend(activation_functions)
    plt.show()

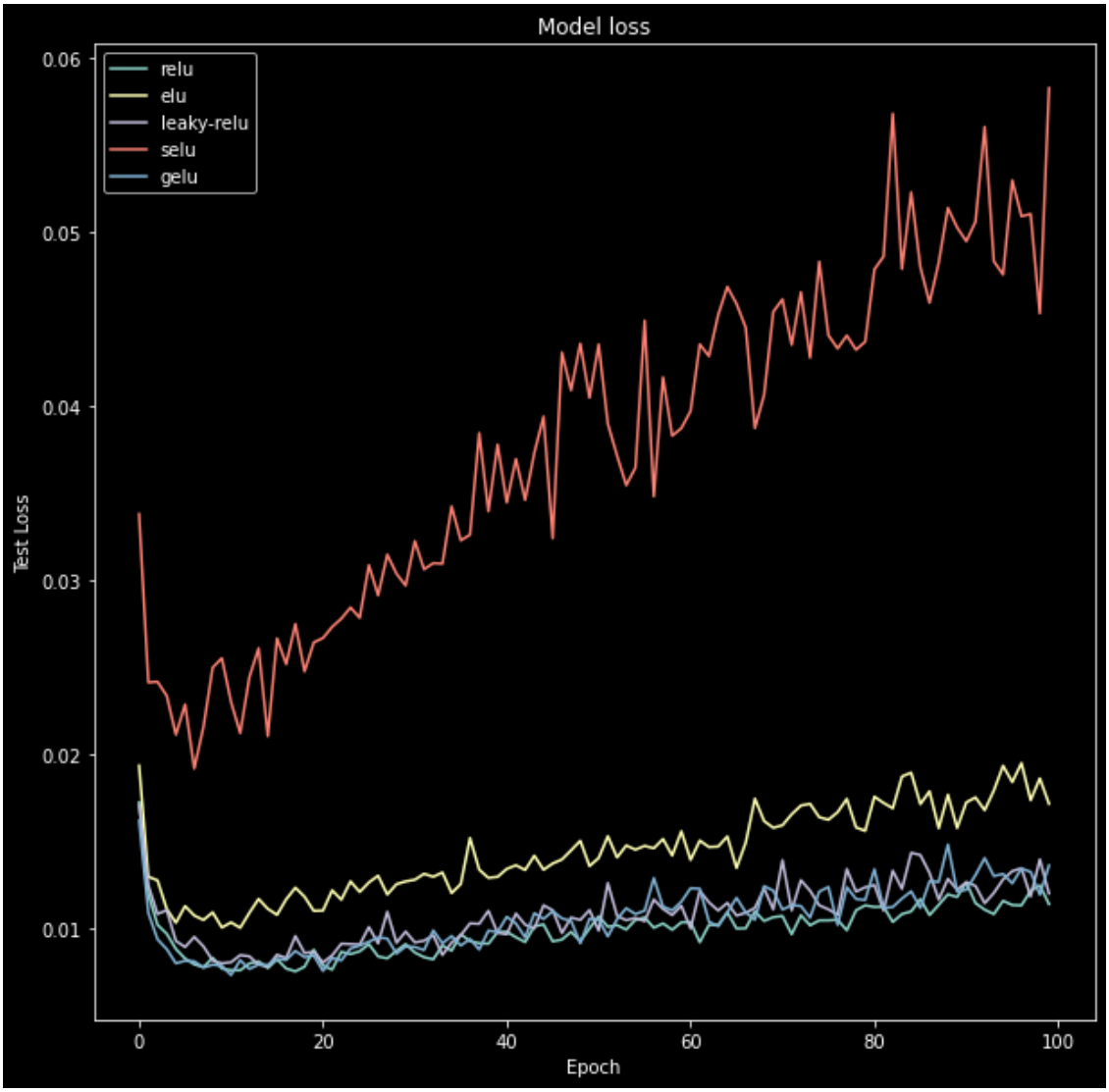
    # Plot validation loss values
    plt.figure(figsize=(10,10))

    for act_func in results:
        plt.plot(act_func.history['val_loss'])

    plt.title('Model loss')
    plt.ylabel('Test Loss')
    plt.xlabel('Epoch')
    plt.legend(activation_functions)
    plt.show()

plot_act_func_results(new_results, new_act_arr)
```


Model accuracy
relu
elu
leaky-relu
selu
gelu
0.990
0.985
0.980
0.975
Test Accuracy
0
20
40
60
80
100
Epoch


Model loss
relu
elu
leaky-relu
selu
gelu
0.06
0.05
0.04
0.03
0.02
0.01
Test Loss
0
20
40
60
80
100
Epoch

[ ]: