

R Notebook

Code ▾

This is an R Markdown (<http://rmarkdown.rstudio.com>) Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter*.

Hide

```
library(keras)
library(reticulate)
```

Attaching package: 'reticulate'

The following object is masked _by_ '.GlobalEnv':

```
install_miniconda
```

Hide

```
library(tensorflow)
```

Attaching package: 'tensorflow'

The following object is masked _by_ '.GlobalEnv':

```
install_tensorflow
```

The following object is masked from 'package:caret':

```
train
```

Hide

```
xx_train <- dat[1:60000,1:784]
yy_train <- to_categorical(dat[1:60000,785])
```

```
Loaded Tensorflow version 2.4.1
```

...

Hide

```
xx_test <- dat[60001:70000,1:784]
yy_test <- to_categorical(dat[60001:70000,785])
```

Hide

```
#Rescale the grayscale images to make the pixel intensity
# on the unit interval
xx_train <- xx_train/255
# massage the data for tensorflow
xx_train<-array_reshape(as.matrix(xx_train),c(60000,784))
xx_test <- xx_test/255
```

Hide

```
# massage the data for tensorflow
xx_test<-array_reshape(as.matrix(xx_test),c(10000,784))
```

Hide

```
# Use the same network structure as used for # the MNist data from class
model_NN <- keras_model_sequential()
```

2022-04-27 09:38:56.191841: I tensorflow/core/platform/cpu_feature_guard.cc:142] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations: SSE4.1 SSE4.2 AVX AVX2 FMA

To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.

Hide

```
model_NN %>%
  layer_dense(units = 256, activation = "relu",
              input_shape = c(784)) %>%
  layer_dropout(rate = 0.4) %>%
  layer_dense(units = 128, activation = "relu") %>% layer_dropout(rate = 0.3) %>%
  layer_dense(units = 10, activation = "softmax")
summary(model_NN)
```

Model: "sequential"

Layer (type) Param #	Output Shape
-------------------------	--------------

dense_2 (Dense) 200960	(None, 256)
---------------------------	-------------

dropout_1 (Dropout) 0	(None, 256)
--------------------------	-------------

dense_1 (Dense) 32896	(None, 128)
--------------------------	-------------

dropout (Dropout) 0	(None, 128)
------------------------	-------------

dense (Dense) 1290	(None, 10)
-----------------------	------------

=====
 Total params: 235,146
 Trainable params: 235,146
 Non-trainable params: 0

[Hide](#)

```
###
model_NN %>% compile(loss = "categorical_crossentropy",
                     optimizer = optimizer_rmsprop(),
                     metrics = c("accuracy")
)
```

[Hide](#)

```
###
system.time(
  history <- model_NN %>%
    fit(xx_train, yy_train, epochs = 30, batch_size = 128,
        validation_split = 0.2)
)
```

```
2022-04-27 09:41:02.886281: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.c
c:116] None of the MLIR optimization passes are enabled (registered 2)
```

Epoch 1/30

```
1/375 [.....] - ETA: 2:47 - loss: 2.3741 - accuracy: 0.093
8
17/375 [>.....] - ETA: 1s - loss: 1.7763 - accuracy: 0.3757

36/375 [=>.....] - ETA: 0s - loss: 1.5225 - accuracy: 0.4674
55/375 [===>.....] - ETA: 0s - loss: 1.3835 - accuracy: 0.5171
73/375 [====>.....] - ETA: 0s - loss: 1.2957 - accuracy: 0.5479
92/375 [=====>.....] - ETA: 0s - loss: 1.2273 - accuracy: 0.5712
111/375 [======>.....] - ETA: 0s - loss: 1.1732 - accuracy: 0.5897
129/375 [======>.....] - ETA: 0s - loss: 1.1312 - accuracy: 0.6043
148/375 [======>.....] - ETA: 0s - loss: 1.0941 - accuracy: 0.6172
167/375 [======>.....] - ETA: 0s - loss: 1.0628 - accuracy: 0.6282
184/375 [======>.....] - ETA: 0s - loss: 1.0381 - accuracy: 0.6367
203/375 [======>.....] - ETA: 0s - loss: 1.0136 - accuracy: 0.6452
221/375 [======>.....] - ETA: 0s - loss: 0.9930 - accuracy: 0.6522
241/375 [======>.....] - ETA: 0s - loss: 0.9726 - accuracy: 0.6592
260/375 [======>.....] - ETA: 0s - loss: 0.9552 - accuracy: 0.6651
278/375 [======>.....] - ETA: 0s - loss: 0.9400 - accuracy: 0.6703
298/375 [======>.....] - ETA: 0s - loss: 0.9243 - accuracy: 0.6756
314/375 [======>.....] - ETA: 0s - loss: 0.9127 - accuracy: 0.6796
333/375 [======>.....] - ETA: 0s - loss: 0.9000 - accuracy: 0.6839
352/375 [======>..] - ETA: 0s - loss: 0.8881 - accuracy: 0.6880
371/375 [======>.] - ETA: 0s - loss: 0.8770 - accuracy: 0.6918
375/375 [=====] - 1s 3ms/step - loss: 0.8748 - accuracy: 0.6
925

375/375 [=====] - 2s 5ms/step - loss: 0.8742 - accuracy: 0.6
927 - val_loss: 0.4474 - val_accuracy: 0.8303
Epoch 2/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.3563 - accuracy: 0.8594
19/375 [>.....] - ETA: 1s - loss: 0.4802 - accuracy: 0.8306
40/375 [==>.....] - ETA: 0s - loss: 0.4884 - accuracy: 0.8269
```

```
59/375 [==>.....] - ETA: 0s - loss: 0.4899 - accuracy: 0.8257
76/375 [=====>.....] - ETA: 0s - loss: 0.4899 - accuracy: 0.8250
96/375 [=====>.....] - ETA: 0s - loss: 0.4898 - accuracy: 0.8245
114/375 [======>.....] - ETA: 0s - loss: 0.4894 - accuracy: 0.8244
131/375 [======>.....] - ETA: 0s - loss: 0.4891 - accuracy: 0.8244
151/375 [======>.....] - ETA: 0s - loss: 0.4888 - accuracy: 0.8243
170/375 [======>.....] - ETA: 0s - loss: 0.4883 - accuracy: 0.8243
190/375 [======>.....] - ETA: 0s - loss: 0.4876 - accuracy: 0.8245
209/375 [======>.....] - ETA: 0s - loss: 0.4868 - accuracy: 0.8247
224/375 [======>.....] - ETA: 0s - loss: 0.4863 - accuracy: 0.8248
240/375 [======>.....] - ETA: 0s - loss: 0.4858 - accuracy: 0.8250
258/375 [======>.....] - ETA: 0s - loss: 0.4853 - accuracy: 0.8252
275/375 [======>.....] - ETA: 0s - loss: 0.4848 - accuracy: 0.8254
292/375 [======>.....] - ETA: 0s - loss: 0.4843 - accuracy: 0.8257
310/375 [======>.....] - ETA: 0s - loss: 0.4837 - accuracy: 0.8259
329/375 [======>....] - ETA: 0s - loss: 0.4831 - accuracy: 0.8261
349/375 [======>...] - ETA: 0s - loss: 0.4825 - accuracy: 0.8264
369/375 [======>.] - ETA: 0s - loss: 0.4818 - accuracy: 0.8266
375/375 [=====] - 1s 3ms/step - loss: 0.4816 - accuracy: 0.8267
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.4816 - accuracy: 0.8267 - val_loss: 0.4044 - val_accuracy: 0.8509
```

Epoch 3/30

```
1/375 [.....] - ETA: 1s - loss: 0.3648 - accuracy: 0.8672
17/375 [>.....] - ETA: 1s - loss: 0.4308 - accuracy: 0.8472
36/375 [=>.....] - ETA: 0s - loss: 0.4407 - accuracy: 0.8422
56/375 [==>.....] - ETA: 0s - loss: 0.4394 - accuracy: 0.8424
76/375 [=====>.....] - ETA: 0s - loss: 0.4382 - accuracy: 0.8422
92/375 [=====>.....] - ETA: 0s - loss: 0.4373 - accuracy: 0.8420
109/375 [======>.....] - ETA: 0s - loss: 0.4371 - accuracy: 0.8419
125/375 [======>.....] - ETA: 0s - loss: 0.4364 - accuracy: 0.8420
141/375 [======>.....] - ETA: 0s - loss: 0.4358 - accuracy: 0.8421
158/375 [======>.....] - ETA: 0s - loss: 0.4354 - accuracy: 0.8423
172/375 [======>.....] - ETA: 0s - loss: 0.4351 - accuracy: 0.8425
190/375 [======>.....] - ETA: 0s - loss: 0.4348 - accuracy: 0.8427
207/375 [======>.....] - ETA: 0s - loss: 0.4346 - accuracy: 0.8428
226/375 [======>.....] - ETA: 0s - loss: 0.4343 - accuracy: 0.8430
245/375 [======>.....] - ETA: 0s - loss: 0.4340 - accuracy: 0.8432
264/375 [======>.....] - ETA: 0s - loss: 0.4338 - accuracy: 0.8434
284/375 [======>.....] - ETA: 0s - loss: 0.4336 - accuracy: 0.8436
302/375 [======>.....] - ETA: 0s - loss: 0.4335 - accuracy: 0.8437
319/375 [======>.....] - ETA: 0s - loss: 0.4335 - accuracy: 0.8438
336/375 [======>....] - ETA: 0s - loss: 0.4334 - accuracy: 0.8439
353/375 [======>...] - ETA: 0s - loss: 0.4333 - accuracy: 0.8440
372/375 [======>.] - ETA: 0s - loss: 0.4330 - accuracy: 0.8441
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.4330 - accuracy: 0.8441
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.4330 - accuracy: 0.8441 - val_loss: 0.3672 - val_accuracy: 0.8659
```

Epoch 4/30

```
1/375 [.....] - ETA: 1s - loss: 0.4725 - accuracy: 0.8359
18/375 [>.....] - ETA: 1s - loss: 0.4376 - accuracy: 0.8478
34/375 [=>.....] - ETA: 1s - loss: 0.4299 - accuracy: 0.8496
53/375 [==>.....] - ETA: 0s - loss: 0.4214 - accuracy: 0.8514
72/375 [===>.....] - ETA: 0s - loss: 0.4174 - accuracy: 0.8521
89/375 [====>.....] - ETA: 0s - loss: 0.4146 - accuracy: 0.8525
107/375 [=====>.....] - ETA: 0s - loss: 0.4128 - accuracy: 0.8528
124/375 [=====>.....] - ETA: 0s - loss: 0.4121 - accuracy: 0.8529
143/375 [======>.....] - ETA: 0s - loss: 0.4117 - accuracy: 0.8528
161/375 [======>.....] - ETA: 0s - loss: 0.4115 - accuracy: 0.8527
172/375 [======>.....] - ETA: 0s - loss: 0.4114 - accuracy: 0.8526
192/375 [======>.....] - ETA: 0s - loss: 0.4113 - accuracy: 0.8525
211/375 [======>.....] - ETA: 0s - loss: 0.4113 - accuracy: 0.8523
229/375 [======>.....] - ETA: 0s - loss: 0.4113 - accuracy: 0.8521
246/375 [======>.....] - ETA: 0s - loss: 0.4111 - accuracy: 0.8520
265/375 [======>.....] - ETA: 0s - loss: 0.4110 - accuracy: 0.8520
283/375 [======>.....] - ETA: 0s - loss: 0.4109 - accuracy: 0.8519
300/375 [======>.....] - ETA: 0s - loss: 0.4107 - accuracy: 0.8519
319/375 [======>.....] - ETA: 0s - loss: 0.4104 - accuracy: 0.8520
338/375 [======>...] - ETA: 0s - loss: 0.4102 - accuracy: 0.8520
357/375 [======>..] - ETA: 0s - loss: 0.4100 - accuracy: 0.8520
375/375 [=====] - 1s 3ms/step - loss: 0.4098 - accuracy: 0.8521
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.4098 - accuracy: 0.8521 - val_loss: 0.3788 - val_accuracy: 0.8626
```

Epoch 5/30

```
1/375 [.....] - ETA: 1s - loss: 0.4199 - accuracy: 0.8594
22/375 [>.....] - ETA: 0s - loss: 0.4111 - accuracy: 0.8609
42/375 [=>.....] - ETA: 0s - loss: 0.4007 - accuracy: 0.8627
63/375 [===>.....] - ETA: 0s - loss: 0.3952 - accuracy: 0.8635
83/375 [====>.....] - ETA: 0s - loss: 0.3947 - accuracy: 0.8625
103/375 [=====>.....] - ETA: 0s - loss: 0.3955 - accuracy: 0.8613
123/375 [=====>.....] - ETA: 0s - loss: 0.3953 - accuracy: 0.8606
144/375 [======>.....] - ETA: 0s - loss: 0.3954 - accuracy: 0.8600
160/375 [======>.....] - ETA: 0s - loss: 0.3954 - accuracy: 0.8597
179/375 [======>.....] - ETA: 0s - loss: 0.3954 - accuracy: 0.8594
196/375 [======>.....] - ETA: 0s - loss: 0.3953 - accuracy: 0.8591
213/375 [======>.....] - ETA: 0s - loss: 0.3952 - accuracy: 0.8590
```

```
231/375 [=====>.....] - ETA: 0s - loss: 0.3951 - accuracy: 0.8589
248/375 [=====>.....] - ETA: 0s - loss: 0.3949 - accuracy: 0.8588
266/375 [=====>.....] - ETA: 0s - loss: 0.3948 - accuracy: 0.8588
284/375 [=====>.....] - ETA: 0s - loss: 0.3946 - accuracy: 0.8588
302/375 [=====>.....] - ETA: 0s - loss: 0.3944 - accuracy: 0.8588
319/375 [=====>.....] - ETA: 0s - loss: 0.3942 - accuracy: 0.8588
338/375 [=====>...] - ETA: 0s - loss: 0.3939 - accuracy: 0.8589
357/375 [=====>..] - ETA: 0s - loss: 0.3937 - accuracy: 0.8590
375/375 [=====] - 1s 3ms/step - loss: 0.3935 - accuracy: 0.8591
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3935 - accuracy: 0.8591 - val_loss: 0.3538 - val_accuracy: 0.8727
```

Epoch 6/30

```
1/375 [.....] - ETA: 1s - loss: 0.4652 - accuracy: 0.8438
19/375 [>.....] - ETA: 0s - loss: 0.3757 - accuracy: 0.8617
37/375 [=>.....] - ETA: 0s - loss: 0.3699 - accuracy: 0.8631
56/375 [==>.....] - ETA: 0s - loss: 0.3683 - accuracy: 0.8643
75/375 [====>.....] - ETA: 0s - loss: 0.3669 - accuracy: 0.8653
93/375 [=====>.....] - ETA: 0s - loss: 0.3670 - accuracy: 0.8656
109/375 [=====>.....] - ETA: 0s - loss: 0.3679 - accuracy: 0.8657
124/375 [=====>.....] - ETA: 0s - loss: 0.3693 - accuracy: 0.8656
141/375 [=====>.....] - ETA: 0s - loss: 0.3704 - accuracy: 0.8656
161/375 [=====>.....] - ETA: 0s - loss: 0.3712 - accuracy: 0.8655
179/375 [=====>.....] - ETA: 0s - loss: 0.3717 - accuracy: 0.8655
196/375 [=====>.....] - ETA: 0s - loss: 0.3720 - accuracy: 0.8655
214/375 [=====>.....] - ETA: 0s - loss: 0.3722 - accuracy: 0.8656
231/375 [=====>.....] - ETA: 0s - loss: 0.3724 - accuracy: 0.8656
248/375 [=====>.....] - ETA: 0s - loss: 0.3726 - accuracy: 0.8657
264/375 [=====>.....] - ETA: 0s - loss: 0.3728 - accuracy: 0.8657
281/375 [=====>.....] - ETA: 0s - loss: 0.3731 - accuracy: 0.8657
298/375 [=====>.....] - ETA: 0s - loss: 0.3734 - accuracy: 0.8657
315/375 [=====>.....] - ETA: 0s - loss: 0.3737 - accuracy: 0.8656
331/375 [=====>.....] - ETA: 0s - loss: 0.3739 - accuracy: 0.8656
346/375 [=====>...] - ETA: 0s - loss: 0.3741 - accuracy: 0.8656
364/375 [=====>.] - ETA: 0s - loss: 0.3744 - accuracy: 0.8656
375/375 [=====] - 1s 3ms/step - loss: 0.3745 - accuracy: 0.8655
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3745 - accuracy: 0.8655 - val_loss: 0.3411 - val_accuracy: 0.8800
```

Epoch 7/30

```
1/375 [.....] - ETA: 1s - loss: 0.3600 - accuracy: 0.8828
17/375 [>.....] - ETA: 1s - loss: 0.3476 - accuracy: 0.8807
31/375 [=>.....] - ETA: 1s - loss: 0.3474 - accuracy: 0.8807
```

```
48/375 [==>.....] - ETA: 1s - loss: 0.3470 - accuracy: 0.8792
66/375 [====>.....] - ETA: 0s - loss: 0.3479 - accuracy: 0.8778
82/375 [=====>.....] - ETA: 0s - loss: 0.3487 - accuracy: 0.8769
98/375 [=====>.....] - ETA: 0s - loss: 0.3500 - accuracy: 0.8759
114/375 [=====>.....] - ETA: 0s - loss: 0.3521 - accuracy: 0.8747
131/375 [=====>.....] - ETA: 0s - loss: 0.3537 - accuracy: 0.8738
147/375 [=====>.....] - ETA: 0s - loss: 0.3550 - accuracy: 0.8731
164/375 [=====>.....] - ETA: 0s - loss: 0.3559 - accuracy: 0.8725
180/375 [=====>.....] - ETA: 0s - loss: 0.3567 - accuracy: 0.8722
197/375 [=====>.....] - ETA: 0s - loss: 0.3573 - accuracy: 0.8719
214/375 [=====>.....] - ETA: 0s - loss: 0.3578 - accuracy: 0.8716
231/375 [=====>.....] - ETA: 0s - loss: 0.3582 - accuracy: 0.8714
249/375 [=====>.....] - ETA: 0s - loss: 0.3585 - accuracy: 0.8712
267/375 [=====>.....] - ETA: 0s - loss: 0.3588 - accuracy: 0.8710
285/375 [=====>.....] - ETA: 0s - loss: 0.3592 - accuracy: 0.8709
301/375 [=====>.....] - ETA: 0s - loss: 0.3595 - accuracy: 0.8708
318/375 [=====>.....] - ETA: 0s - loss: 0.3598 - accuracy: 0.8707
335/375 [=====>.....] - ETA: 0s - loss: 0.3601 - accuracy: 0.8706
352/375 [=====>.....] - ETA: 0s - loss: 0.3604 - accuracy: 0.8705
370/375 [=====>.....] - ETA: 0s - loss: 0.3607 - accuracy: 0.8704
375/375 [=====>.....] - 1s 3ms/step - loss: 0.3607 - accuracy: 0.8704
```

```
375/375 [=====>.....] - 1s 4ms/step - loss: 0.3608 - accuracy: 0.8704 - val_loss: 0.3459 - val_accuracy: 0.8758
Epoch 8/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2528 - accuracy: 0.9141
19/375 [>.....] - ETA: 1s - loss: 0.3432 - accuracy: 0.8795
37/375 [=>.....] - ETA: 0s - loss: 0.3445 - accuracy: 0.8783
55/375 [==>.....] - ETA: 0s - loss: 0.3436 - accuracy: 0.8772
72/375 [====>.....] - ETA: 0s - loss: 0.3444 - accuracy: 0.8767
91/375 [=====>.....] - ETA: 0s - loss: 0.3452 - accuracy: 0.8762
108/375 [=====>.....] - ETA: 0s - loss: 0.3457 - accuracy: 0.8759
127/375 [=====>.....] - ETA: 0s - loss: 0.3462 - accuracy: 0.8757
144/375 [=====>.....] - ETA: 0s - loss: 0.3468 - accuracy: 0.8755
161/375 [=====>.....] - ETA: 0s - loss: 0.3473 - accuracy: 0.8754
178/375 [=====>.....] - ETA: 0s - loss: 0.3479 - accuracy: 0.8752
196/375 [=====>.....] - ETA: 0s - loss: 0.3485 - accuracy: 0.8751
210/375 [=====>.....] - ETA: 0s - loss: 0.3490 - accuracy: 0.8750
227/375 [=====>.....] - ETA: 0s - loss: 0.3496 - accuracy: 0.8749
245/375 [=====>.....] - ETA: 0s - loss: 0.3502 - accuracy: 0.8748
262/375 [=====>.....] - ETA: 0s - loss: 0.3508 - accuracy: 0.8747
279/375 [=====>.....] - ETA: 0s - loss: 0.3513 - accuracy: 0.8745
296/375 [=====>.....] - ETA: 0s - loss: 0.3516 - accuracy: 0.8744
313/375 [=====>.....] - ETA: 0s - loss: 0.3518 - accuracy: 0.8744
330/375 [=====>.....] - ETA: 0s - loss: 0.3520 - accuracy: 0.8743
```



```
347/375 [=====>...] - ETA: 0s - loss: 0.3522 - accuracy: 0.8743
364/375 [=====>.] - ETA: 0s - loss: 0.3525 - accuracy: 0.8742
375/375 [=====] - 1s 3ms/step - loss: 0.3526 - accuracy: 0.8741
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3526 - accuracy: 0.8741 - val_loss: 0.3579 - val_accuracy: 0.8764
Epoch 9/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.3582 - accuracy: 0.8516
19/375 [>.....] - ETA: 1s - loss: 0.3611 - accuracy: 0.8657
35/375 [= >.....] - ETA: 1s - loss: 0.3609 - accuracy: 0.8651
53/375 [== >.....] - ETA: 0s - loss: 0.3592 - accuracy: 0.8653
71/375 [=== >.....] - ETA: 0s - loss: 0.3582 - accuracy: 0.8664
88/375 [==== >.....] - ETA: 0s - loss: 0.3578 - accuracy: 0.8673
105/375 [===== >.....] - ETA: 0s - loss: 0.3570 - accuracy: 0.8678
122/375 [===== >.....] - ETA: 0s - loss: 0.3559 - accuracy: 0.8682
138/375 [===== >.....] - ETA: 0s - loss: 0.3550 - accuracy: 0.8686
153/375 [===== >.....] - ETA: 0s - loss: 0.3540 - accuracy: 0.8690
170/375 [===== >.....] - ETA: 0s - loss: 0.3533 - accuracy: 0.8693
187/375 [===== >.....] - ETA: 0s - loss: 0.3528 - accuracy: 0.8696
204/375 [===== >.....] - ETA: 0s - loss: 0.3524 - accuracy: 0.8697
220/375 [===== >.....] - ETA: 0s - loss: 0.3521 - accuracy: 0.8699
235/375 [===== >.....] - ETA: 0s - loss: 0.3518 - accuracy: 0.8700
248/375 [===== >.....] - ETA: 0s - loss: 0.3516 - accuracy: 0.8702
264/375 [===== >.....] - ETA: 0s - loss: 0.3513 - accuracy: 0.8703
282/375 [===== >.....] - ETA: 0s - loss: 0.3511 - accuracy: 0.8705
300/375 [===== >.....] - ETA: 0s - loss: 0.3509 - accuracy: 0.8706
317/375 [===== >.....] - ETA: 0s - loss: 0.3508 - accuracy: 0.8707
334/375 [===== >....] - ETA: 0s - loss: 0.3508 - accuracy: 0.8708
349/375 [===== >...] - ETA: 0s - loss: 0.3509 - accuracy: 0.8709
365/375 [===== >.] - ETA: 0s - loss: 0.3509 - accuracy: 0.8709
375/375 [=====] - 1s 3ms/step - loss: 0.3509 - accuracy: 0.8710
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.3509 - accuracy: 0.8710 - val_loss: 0.3550 - val_accuracy: 0.8783
Epoch 10/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2824 - accuracy: 0.8750
19/375 [>.....] - ETA: 1s - loss: 0.3538 - accuracy: 0.8704
36/375 [= >.....] - ETA: 0s - loss: 0.3557 - accuracy: 0.8711
55/375 [== >.....] - ETA: 0s - loss: 0.3531 - accuracy: 0.8719
73/375 [=== >.....] - ETA: 0s - loss: 0.3524 - accuracy: 0.8721
89/375 [==== >.....] - ETA: 0s - loss: 0.3518 - accuracy: 0.8722
105/375 [===== >.....] - ETA: 0s - loss: 0.3514 - accuracy: 0.8725
122/375 [===== >.....] - ETA: 0s - loss: 0.3515 - accuracy: 0.8726
```

```
138/375 [=====>.....] - ETA: 0s - loss: 0.3515 - accuracy: 0.8728
154/375 [=====>.....] - ETA: 0s - loss: 0.3513 - accuracy: 0.8729
170/375 [=====>.....] - ETA: 0s - loss: 0.3512 - accuracy: 0.8730
183/375 [=====>.....] - ETA: 0s - loss: 0.3510 - accuracy: 0.8731
196/375 [=====>.....] - ETA: 0s - loss: 0.3509 - accuracy: 0.8733
212/375 [=====>.....] - ETA: 0s - loss: 0.3508 - accuracy: 0.8734
230/375 [=====>.....] - ETA: 0s - loss: 0.3506 - accuracy: 0.8734
247/375 [=====>.....] - ETA: 0s - loss: 0.3504 - accuracy: 0.8735
263/375 [=====>.....] - ETA: 0s - loss: 0.3503 - accuracy: 0.8736
281/375 [=====>.....] - ETA: 0s - loss: 0.3501 - accuracy: 0.8737
298/375 [=====>.....] - ETA: 0s - loss: 0.3499 - accuracy: 0.8737
316/375 [=====>.....] - ETA: 0s - loss: 0.3498 - accuracy: 0.8737
332/375 [=====>....] - ETA: 0s - loss: 0.3497 - accuracy: 0.8738
348/375 [=====>...] - ETA: 0s - loss: 0.3496 - accuracy: 0.8739
364/375 [=====>.] - ETA: 0s - loss: 0.3494 - accuracy: 0.8740
375/375 [=====] - 1s 3ms/step - loss: 0.3493 - accuracy: 0.8740
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.3493 - accuracy: 0.8740 - val_loss: 0.3428 - val_accuracy: 0.8781
Epoch 11/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.3223 - accuracy: 0.8906
18/375 [>.....] - ETA: 1s - loss: 0.3390 - accuracy: 0.8846
36/375 [=>.....] - ETA: 0s - loss: 0.3386 - accuracy: 0.8841
53/375 [==>.....] - ETA: 0s - loss: 0.3391 - accuracy: 0.8830
70/375 [===>.....] - ETA: 0s - loss: 0.3384 - accuracy: 0.8821
86/375 [====>.....] - ETA: 0s - loss: 0.3374 - accuracy: 0.8817
104/375 [=====>.....] - ETA: 0s - loss: 0.3365 - accuracy: 0.8813
122/375 [=====>.....] - ETA: 0s - loss: 0.3362 - accuracy: 0.8807
137/375 [=====>.....] - ETA: 0s - loss: 0.3362 - accuracy: 0.8804
153/375 [=====>.....] - ETA: 0s - loss: 0.3364 - accuracy: 0.8801
169/375 [=====>.....] - ETA: 0s - loss: 0.3366 - accuracy: 0.8799
185/375 [=====>.....] - ETA: 0s - loss: 0.3368 - accuracy: 0.8797
201/375 [=====>.....] - ETA: 0s - loss: 0.3371 - accuracy: 0.8796
216/375 [=====>.....] - ETA: 0s - loss: 0.3374 - accuracy: 0.8794
232/375 [=====>.....] - ETA: 0s - loss: 0.3375 - accuracy: 0.8793
247/375 [=====>.....] - ETA: 0s - loss: 0.3374 - accuracy: 0.8793
263/375 [=====>.....] - ETA: 0s - loss: 0.3374 - accuracy: 0.8793
279/375 [=====>.....] - ETA: 0s - loss: 0.3374 - accuracy: 0.8793
295/375 [=====>.....] - ETA: 0s - loss: 0.3375 - accuracy: 0.8794
311/375 [=====>.....] - ETA: 0s - loss: 0.3375 - accuracy: 0.8794
329/375 [=====>....] - ETA: 0s - loss: 0.3376 - accuracy: 0.8794
344/375 [=====>...] - ETA: 0s - loss: 0.3377 - accuracy: 0.8793
359/375 [=====>.] - ETA: 0s - loss: 0.3379 - accuracy: 0.8793
375/375 [=====] - 1s 3ms/step - loss: 0.3379 - accuracy: 0.8794
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.3380 - accuracy: 0.8
794 - val_loss: 0.3363 - val_accuracy: 0.8856
```

Epoch 12/30

```
1/375 [.....] - ETA: 1s - loss: 0.2577 - accuracy: 0.9219
18/375 [>.....] - ETA: 1s - loss: 0.2996 - accuracy: 0.8954
36/375 [=>.....] - ETA: 1s - loss: 0.3119 - accuracy: 0.8907
54/375 [===>.....] - ETA: 0s - loss: 0.3168 - accuracy: 0.8882
70/375 [====>.....] - ETA: 0s - loss: 0.3192 - accuracy: 0.8869
85/375 [=====>.....] - ETA: 0s - loss: 0.3201 - accuracy: 0.8861
101/375 [======>.....] - ETA: 0s - loss: 0.3201 - accuracy: 0.8857
118/375 [======>.....] - ETA: 0s - loss: 0.3205 - accuracy: 0.8853
135/375 [======>.....] - ETA: 0s - loss: 0.3213 - accuracy: 0.8849
152/375 [======>.....] - ETA: 0s - loss: 0.3220 - accuracy: 0.8846
171/375 [======>.....] - ETA: 0s - loss: 0.3225 - accuracy: 0.8842
190/375 [======>.....] - ETA: 0s - loss: 0.3229 - accuracy: 0.8840
206/375 [======>.....] - ETA: 0s - loss: 0.3233 - accuracy: 0.8838
222/375 [======>.....] - ETA: 0s - loss: 0.3238 - accuracy: 0.8837
237/375 [======>.....] - ETA: 0s - loss: 0.3242 - accuracy: 0.8835
253/375 [======>.....] - ETA: 0s - loss: 0.3246 - accuracy: 0.8834
269/375 [======>.....] - ETA: 0s - loss: 0.3250 - accuracy: 0.8833
286/375 [======>.....] - ETA: 0s - loss: 0.3253 - accuracy: 0.8832
304/375 [======>.....] - ETA: 0s - loss: 0.3257 - accuracy: 0.8831
320/375 [======>.....] - ETA: 0s - loss: 0.3261 - accuracy: 0.8830
337/375 [======>.....] - ETA: 0s - loss: 0.3264 - accuracy: 0.8830
353/375 [======>..] - ETA: 0s - loss: 0.3267 - accuracy: 0.8829
369/375 [======>.] - ETA: 0s - loss: 0.3270 - accuracy: 0.8828
375/375 [=====] - 1s 3ms/step - loss: 0.3271 - accuracy: 0.8
828
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3271 - accuracy: 0.8
828 - val_loss: 0.3434 - val_accuracy: 0.8834
```

Epoch 13/30

```
1/375 [.....] - ETA: 1s - loss: 0.2167 - accuracy: 0.9062
19/375 [>.....] - ETA: 0s - loss: 0.3146 - accuracy: 0.8837
37/375 [=>.....] - ETA: 0s - loss: 0.3212 - accuracy: 0.8815
53/375 [===>.....] - ETA: 0s - loss: 0.3229 - accuracy: 0.8812
71/375 [====>.....] - ETA: 0s - loss: 0.3236 - accuracy: 0.8813
87/375 [=====>.....] - ETA: 0s - loss: 0.3242 - accuracy: 0.8813
103/375 [======>.....] - ETA: 0s - loss: 0.3253 - accuracy: 0.8812
122/375 [======>.....] - ETA: 0s - loss: 0.3266 - accuracy: 0.8811
139/375 [======>.....] - ETA: 0s - loss: 0.3271 - accuracy: 0.8810
155/375 [======>.....] - ETA: 0s - loss: 0.3273 - accuracy: 0.8810
172/375 [======>.....] - ETA: 0s - loss: 0.3276 - accuracy: 0.8810
189/375 [======>.....] - ETA: 0s - loss: 0.3277 - accuracy: 0.8809
```

```
206/375 [=====>.....] - ETA: 0s - loss: 0.3280 - accuracy: 0.8809
222/375 [=====>.....] - ETA: 0s - loss: 0.3283 - accuracy: 0.8809
239/375 [=====>.....] - ETA: 0s - loss: 0.3285 - accuracy: 0.8809
256/375 [=====>.....] - ETA: 0s - loss: 0.3287 - accuracy: 0.8809
273/375 [=====>.....] - ETA: 0s - loss: 0.3288 - accuracy: 0.8809
290/375 [=====>.....] - ETA: 0s - loss: 0.3289 - accuracy: 0.8808
307/375 [=====>.....] - ETA: 0s - loss: 0.3290 - accuracy: 0.8808
324/375 [=====>.....] - ETA: 0s - loss: 0.3290 - accuracy: 0.8808
341/375 [=====>....] - ETA: 0s - loss: 0.3290 - accuracy: 0.8809
359/375 [=====>..] - ETA: 0s - loss: 0.3290 - accuracy: 0.8809
375/375 [=====] - 1s 3ms/step - loss: 0.3290 - accuracy: 0.8809
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3290 - accuracy: 0.8809 - val_loss: 0.3486 - val_accuracy: 0.8814
Epoch 14/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2867 - accuracy: 0.8750
14/375 [>.....] - ETA: 1s - loss: 0.3613 - accuracy: 0.8679
33/375 [=>.....] - ETA: 1s - loss: 0.3433 - accuracy: 0.8774
52/375 [==>.....] - ETA: 0s - loss: 0.3353 - accuracy: 0.8813
69/375 [===>.....] - ETA: 0s - loss: 0.3313 - accuracy: 0.8829
86/375 [====>.....] - ETA: 0s - loss: 0.3288 - accuracy: 0.8837
105/375 [=====>.....] - ETA: 0s - loss: 0.3272 - accuracy: 0.8843
123/375 [=====>.....] - ETA: 0s - loss: 0.3266 - accuracy: 0.8848
141/375 [=====>.....] - ETA: 0s - loss: 0.3265 - accuracy: 0.8850
158/375 [=====>.....] - ETA: 0s - loss: 0.3264 - accuracy: 0.8851
174/375 [=====>.....] - ETA: 0s - loss: 0.3263 - accuracy: 0.8851
190/375 [=====>.....] - ETA: 0s - loss: 0.3260 - accuracy: 0.8852
205/375 [=====>.....] - ETA: 0s - loss: 0.3258 - accuracy: 0.8853
222/375 [=====>.....] - ETA: 0s - loss: 0.3256 - accuracy: 0.8853
238/375 [=====>.....] - ETA: 0s - loss: 0.3254 - accuracy: 0.8853
255/375 [=====>.....] - ETA: 0s - loss: 0.3252 - accuracy: 0.8853
273/375 [=====>.....] - ETA: 0s - loss: 0.3251 - accuracy: 0.8853
292/375 [=====>.....] - ETA: 0s - loss: 0.3250 - accuracy: 0.8853
309/375 [=====>.....] - ETA: 0s - loss: 0.3249 - accuracy: 0.8852
327/375 [=====>....] - ETA: 0s - loss: 0.3249 - accuracy: 0.8852
344/375 [=====>...] - ETA: 0s - loss: 0.3249 - accuracy: 0.8852
361/375 [=====>..] - ETA: 0s - loss: 0.3250 - accuracy: 0.8852
375/375 [=====] - 1s 3ms/step - loss: 0.3251 - accuracy: 0.8851
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3251 - accuracy: 0.8851 - val_loss: 0.3303 - val_accuracy: 0.8906
Epoch 15/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.4495 - accuracy: 0.8047
```

```
20/375 [>.....] - ETA: 0s - loss: 0.3282 - accuracy: 0.8728
40/375 [==>.....] - ETA: 0s - loss: 0.3207 - accuracy: 0.8790
55/375 [===>.....] - ETA: 0s - loss: 0.3196 - accuracy: 0.8806
64/375 [====>.....] - ETA: 1s - loss: 0.3200 - accuracy: 0.8811
82/375 [=====>.....] - ETA: 0s - loss: 0.3211 - accuracy: 0.8819
101/375 [=====>.....] - ETA: 0s - loss: 0.3212 - accuracy: 0.8826
119/375 [======>.....] - ETA: 0s - loss: 0.3206 - accuracy: 0.8833
136/375 [======>.....] - ETA: 0s - loss: 0.3200 - accuracy: 0.8838
153/375 [======>.....] - ETA: 0s - loss: 0.3197 - accuracy: 0.8840
170/375 [======>.....] - ETA: 0s - loss: 0.3198 - accuracy: 0.8841
187/375 [======>.....] - ETA: 0s - loss: 0.3199 - accuracy: 0.8842
205/375 [======>.....] - ETA: 0s - loss: 0.3199 - accuracy: 0.8843
223/375 [======>.....] - ETA: 0s - loss: 0.3201 - accuracy: 0.8844
239/375 [======>.....] - ETA: 0s - loss: 0.3203 - accuracy: 0.8844
255/375 [======>.....] - ETA: 0s - loss: 0.3205 - accuracy: 0.8844
270/375 [======>.....] - ETA: 0s - loss: 0.3208 - accuracy: 0.8844
288/375 [======>.....] - ETA: 0s - loss: 0.3210 - accuracy: 0.8844
306/375 [======>.....] - ETA: 0s - loss: 0.3212 - accuracy: 0.8844
326/375 [======>.....] - ETA: 0s - loss: 0.3214 - accuracy: 0.8843
342/375 [======>...] - ETA: 0s - loss: 0.3215 - accuracy: 0.8843
358/375 [======>..] - ETA: 0s - loss: 0.3216 - accuracy: 0.8843
375/375 [=====] - 1s 3ms/step - loss: 0.3217 - accuracy: 0.8843
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3217 - accuracy: 0.8843 - val_loss: 0.3486 - val_accuracy: 0.8882
Epoch 16/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2536 - accuracy: 0.8906
17/375 [>.....] - ETA: 1s - loss: 0.2952 - accuracy: 0.8864
30/375 [=>.....] - ETA: 1s - loss: 0.3012 - accuracy: 0.8868
40/375 [==>.....] - ETA: 1s - loss: 0.3044 - accuracy: 0.8875
57/375 [===>.....] - ETA: 1s - loss: 0.3096 - accuracy: 0.8870
75/375 [====>.....] - ETA: 1s - loss: 0.3126 - accuracy: 0.8864
94/375 [=====>.....] - ETA: 0s - loss: 0.3142 - accuracy: 0.8860
112/375 [=====>.....] - ETA: 0s - loss: 0.3148 - accuracy: 0.8860
129/375 [======>.....] - ETA: 0s - loss: 0.3153 - accuracy: 0.8859
145/375 [======>.....] - ETA: 0s - loss: 0.3160 - accuracy: 0.8859
166/375 [======>.....] - ETA: 0s - loss: 0.3167 - accuracy: 0.8859
184/375 [======>.....] - ETA: 0s - loss: 0.3170 - accuracy: 0.8859
201/375 [======>.....] - ETA: 0s - loss: 0.3173 - accuracy: 0.8859
218/375 [======>.....] - ETA: 0s - loss: 0.3175 - accuracy: 0.8859
236/375 [======>.....] - ETA: 0s - loss: 0.3177 - accuracy: 0.8859
253/375 [======>.....] - ETA: 0s - loss: 0.3177 - accuracy: 0.8860
270/375 [======>.....] - ETA: 0s - loss: 0.3176 - accuracy: 0.8861
287/375 [======>.....] - ETA: 0s - loss: 0.3176 - accuracy: 0.8862
304/375 [======>.....] - ETA: 0s - loss: 0.3177 - accuracy: 0.8862
```

```
320/375 [=====>.....] - ETA: 0s - loss: 0.3178 - accuracy: 0.8862
338/375 [=====>...] - ETA: 0s - loss: 0.3180 - accuracy: 0.8862
355/375 [=====>..] - ETA: 0s - loss: 0.3180 - accuracy: 0.8862
372/375 [=====>.] - ETA: 0s - loss: 0.3181 - accuracy: 0.8861
375/375 [=====] - 1s 3ms/step - loss: 0.3181 - accuracy: 0.8
861
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.3181 - accuracy: 0.8
861 - val_loss: 0.3465 - val_accuracy: 0.8896
Epoch 17/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2545 - accuracy: 0.9062
17/375 [>.....] - ETA: 1s - loss: 0.2797 - accuracy: 0.8887
35/375 [=>.....] - ETA: 1s - loss: 0.2879 - accuracy: 0.8876
55/375 [===>.....] - ETA: 0s - loss: 0.2910 - accuracy: 0.8880
74/375 [====>.....] - ETA: 0s - loss: 0.2921 - accuracy: 0.8887
91/375 [=====>.....] - ETA: 0s - loss: 0.2944 - accuracy: 0.8888
108/375 [=====>.....] - ETA: 0s - loss: 0.2964 - accuracy: 0.8887
126/375 [=====>.....] - ETA: 0s - loss: 0.2983 - accuracy: 0.8887
144/375 [=====>.....] - ETA: 0s - loss: 0.3006 - accuracy: 0.8884
158/375 [=====>.....] - ETA: 0s - loss: 0.3022 - accuracy: 0.8881
171/375 [=====>.....] - ETA: 0s - loss: 0.3034 - accuracy: 0.8879
185/375 [=====>.....] - ETA: 0s - loss: 0.3047 - accuracy: 0.8877
202/375 [=====>.....] - ETA: 0s - loss: 0.3060 - accuracy: 0.8874
219/375 [=====>.....] - ETA: 0s - loss: 0.3071 - accuracy: 0.8871
231/375 [=====>.....] - ETA: 0s - loss: 0.3078 - accuracy: 0.8870
247/375 [=====>.....] - ETA: 0s - loss: 0.3085 - accuracy: 0.8868
264/375 [=====>.....] - ETA: 0s - loss: 0.3092 - accuracy: 0.8866
280/375 [=====>.....] - ETA: 0s - loss: 0.3099 - accuracy: 0.8864
297/375 [=====>.....] - ETA: 0s - loss: 0.3103 - accuracy: 0.8863
314/375 [=====>.....] - ETA: 0s - loss: 0.3107 - accuracy: 0.8862
330/375 [=====>....] - ETA: 0s - loss: 0.3111 - accuracy: 0.8861
348/375 [=====>...] - ETA: 0s - loss: 0.3114 - accuracy: 0.8860
363/375 [=====>.] - ETA: 0s - loss: 0.3117 - accuracy: 0.8859
375/375 [=====] - 1s 3ms/step - loss: 0.3120 - accuracy: 0.8
859
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.3120 - accuracy: 0.8
859 - val_loss: 0.3417 - val_accuracy: 0.8853
Epoch 18/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.3279 - accuracy: 0.8750
19/375 [>.....] - ETA: 1s - loss: 0.3017 - accuracy: 0.8922
38/375 [==>.....] - ETA: 0s - loss: 0.2979 - accuracy: 0.8904
54/375 [===>.....] - ETA: 0s - loss: 0.3001 - accuracy: 0.8890
72/375 [====>.....] - ETA: 0s - loss: 0.3035 - accuracy: 0.8874
91/375 [=====>.....] - ETA: 0s - loss: 0.3056 - accuracy: 0.8869
```

```
111/375 [=====>.....] - ETA: 0s - loss: 0.3070 - accuracy: 0.8866
129/375 [=====>.....] - ETA: 0s - loss: 0.3082 - accuracy: 0.8862
144/375 [=====>.....] - ETA: 0s - loss: 0.3090 - accuracy: 0.8860
160/375 [=====>.....] - ETA: 0s - loss: 0.3099 - accuracy: 0.8858
177/375 [=====>.....] - ETA: 0s - loss: 0.3109 - accuracy: 0.8856
194/375 [=====>.....] - ETA: 0s - loss: 0.3115 - accuracy: 0.8854
211/375 [=====>.....] - ETA: 0s - loss: 0.3122 - accuracy: 0.8853
228/375 [=====>.....] - ETA: 0s - loss: 0.3127 - accuracy: 0.8852
245/375 [=====>.....] - ETA: 0s - loss: 0.3132 - accuracy: 0.8852
264/375 [=====>.....] - ETA: 0s - loss: 0.3136 - accuracy: 0.8851
283/375 [=====>.....] - ETA: 0s - loss: 0.3139 - accuracy: 0.8851
301/375 [=====>.....] - ETA: 0s - loss: 0.3141 - accuracy: 0.8851
318/375 [=====>.....] - ETA: 0s - loss: 0.3143 - accuracy: 0.8852
336/375 [=====>.....] - ETA: 0s - loss: 0.3145 - accuracy: 0.8852
354/375 [=====>.....] - ETA: 0s - loss: 0.3146 - accuracy: 0.8853
371/375 [=====>.....] - ETA: 0s - loss: 0.3147 - accuracy: 0.8854
375/375 [=====>.....] - 1s 3ms/step - loss: 0.3147 - accuracy: 0.8854
```

```
375/375 [=====>.....] - 1s 3ms/step - loss: 0.3147 - accuracy: 0.8854 - val_loss: 0.3422 - val_accuracy: 0.8873
Epoch 19/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2329 - accuracy: 0.8984
18/375 [>.....] - ETA: 1s - loss: 0.3349 - accuracy: 0.8820
35/375 [=.....] - ETA: 1s - loss: 0.3303 - accuracy: 0.8846
53/375 [====>.....] - ETA: 0s - loss: 0.3266 - accuracy: 0.8864
72/375 [====>.....] - ETA: 0s - loss: 0.3242 - accuracy: 0.8870
88/375 [=====>.....] - ETA: 0s - loss: 0.3232 - accuracy: 0.8870
105/375 [=====>.....] - ETA: 0s - loss: 0.3227 - accuracy: 0.8868
121/375 [=====>.....] - ETA: 0s - loss: 0.3223 - accuracy: 0.8867
138/375 [=====>.....] - ETA: 0s - loss: 0.3221 - accuracy: 0.8867
155/375 [=====>.....] - ETA: 0s - loss: 0.3217 - accuracy: 0.8867
172/375 [=====>.....] - ETA: 0s - loss: 0.3214 - accuracy: 0.8867
189/375 [=====>.....] - ETA: 0s - loss: 0.3211 - accuracy: 0.8866
203/375 [=====>.....] - ETA: 0s - loss: 0.3208 - accuracy: 0.8866
219/375 [=====>.....] - ETA: 0s - loss: 0.3204 - accuracy: 0.8866
234/375 [=====>.....] - ETA: 0s - loss: 0.3201 - accuracy: 0.8866
251/375 [=====>.....] - ETA: 0s - loss: 0.3199 - accuracy: 0.8866
267/375 [=====>.....] - ETA: 0s - loss: 0.3198 - accuracy: 0.8866
283/375 [=====>.....] - ETA: 0s - loss: 0.3197 - accuracy: 0.8866
299/375 [=====>.....] - ETA: 0s - loss: 0.3197 - accuracy: 0.8866
316/375 [=====>.....] - ETA: 0s - loss: 0.3196 - accuracy: 0.8866
333/375 [=====>.....] - ETA: 0s - loss: 0.3194 - accuracy: 0.8866
350/375 [=====>.....] - ETA: 0s - loss: 0.3193 - accuracy: 0.8866
368/375 [=====>.....] - ETA: 0s - loss: 0.3192 - accuracy: 0.8866
375/375 [=====>.....] - 1s 3ms/step - loss: 0.3192 - accuracy: 0.8866
```

866

```
375/375 [=====] - 1s 3ms/step - loss: 0.3191 - accuracy: 0.8
866 - val_loss: 0.3395 - val_accuracy: 0.8903
Epoch 20/30
```

```
 1/375 [.....] - ETA: 1s - loss: 0.4282 - accuracy: 0.8594
18/375 [>.....] - ETA: 1s - loss: 0.3556 - accuracy: 0.8589
37/375 [=.....] - ETA: 0s - loss: 0.3288 - accuracy: 0.8730
57/375 [===>.....] - ETA: 0s - loss: 0.3190 - accuracy: 0.8789
77/375 [====>.....] - ETA: 0s - loss: 0.3150 - accuracy: 0.8820
95/375 [=====>.....] - ETA: 0s - loss: 0.3144 - accuracy: 0.8833
113/375 [=====>.....] - ETA: 0s - loss: 0.3140 - accuracy: 0.8842
130/375 [=====>.....] - ETA: 0s - loss: 0.3140 - accuracy: 0.8848
148/375 [=====>.....] - ETA: 0s - loss: 0.3138 - accuracy: 0.8854
167/375 [=====>.....] - ETA: 0s - loss: 0.3137 - accuracy: 0.8859
183/375 [=====>.....] - ETA: 0s - loss: 0.3135 - accuracy: 0.8863
201/375 [=====>.....] - ETA: 0s - loss: 0.3132 - accuracy: 0.8867
218/375 [=====>.....] - ETA: 0s - loss: 0.3130 - accuracy: 0.8870
236/375 [=====>.....] - ETA: 0s - loss: 0.3131 - accuracy: 0.8872
254/375 [=====>.....] - ETA: 0s - loss: 0.3131 - accuracy: 0.8874
273/375 [=====>.....] - ETA: 0s - loss: 0.3130 - accuracy: 0.8876
290/375 [=====>.....] - ETA: 0s - loss: 0.3128 - accuracy: 0.8877
305/375 [=====>.....] - ETA: 0s - loss: 0.3127 - accuracy: 0.8879
322/375 [=====>.....] - ETA: 0s - loss: 0.3126 - accuracy: 0.8880
339/375 [=====>...] - ETA: 0s - loss: 0.3126 - accuracy: 0.8881
356/375 [=====>..] - ETA: 0s - loss: 0.3125 - accuracy: 0.8882
373/375 [=====>.] - ETA: 0s - loss: 0.3124 - accuracy: 0.8883
375/375 [=====] - 1s 3ms/step - loss: 0.3124 - accuracy: 0.8
883
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3124 - accuracy: 0.8
883 - val_loss: 0.3393 - val_accuracy: 0.8904
Epoch 21/30
```

```
 1/375 [.....] - ETA: 1s - loss: 0.2027 - accuracy: 0.9453
18/375 [>.....] - ETA: 1s - loss: 0.2783 - accuracy: 0.9072
36/375 [=.....] - ETA: 0s - loss: 0.2940 - accuracy: 0.9013
55/375 [===>.....] - ETA: 0s - loss: 0.2992 - accuracy: 0.8988
73/375 [====>.....] - ETA: 0s - loss: 0.3015 - accuracy: 0.8971
90/375 [=====>.....] - ETA: 0s - loss: 0.3034 - accuracy: 0.8960
106/375 [=====>.....] - ETA: 0s - loss: 0.3040 - accuracy: 0.8955
122/375 [=====>.....] - ETA: 0s - loss: 0.3045 - accuracy: 0.8951
139/375 [=====>.....] - ETA: 0s - loss: 0.3048 - accuracy: 0.8949
157/375 [=====>.....] - ETA: 0s - loss: 0.3050 - accuracy: 0.8946
174/375 [=====>.....] - ETA: 0s - loss: 0.3052 - accuracy: 0.8945
193/375 [=====>.....] - ETA: 0s - loss: 0.3054 - accuracy: 0.8943
```



```
211/375 [=====>.....] - ETA: 0s - loss: 0.3054 - accuracy: 0.8942
228/375 [=====>.....] - ETA: 0s - loss: 0.3054 - accuracy: 0.8942
245/375 [=====>.....] - ETA: 0s - loss: 0.3055 - accuracy: 0.8942
263/375 [=====>.....] - ETA: 0s - loss: 0.3056 - accuracy: 0.8941
280/375 [=====>.....] - ETA: 0s - loss: 0.3057 - accuracy: 0.8940
297/375 [=====>.....] - ETA: 0s - loss: 0.3058 - accuracy: 0.8940
313/375 [=====>.....] - ETA: 0s - loss: 0.3059 - accuracy: 0.8939
330/375 [=====>....] - ETA: 0s - loss: 0.3061 - accuracy: 0.8938
347/375 [=====>...] - ETA: 0s - loss: 0.3062 - accuracy: 0.8937
365/375 [=====>.] - ETA: 0s - loss: 0.3064 - accuracy: 0.8936
375/375 [=====] - 1s 3ms/step - loss: 0.3065 - accuracy: 0.8935
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3065 - accuracy: 0.8935 - val_loss: 0.3540 - val_accuracy: 0.8852
Epoch 22/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2342 - accuracy: 0.9141
18/375 [>.....] - ETA: 1s - loss: 0.2894 - accuracy: 0.8927
37/375 [=>.....] - ETA: 0s - loss: 0.2952 - accuracy: 0.8897
55/375 [==>.....] - ETA: 0s - loss: 0.2953 - accuracy: 0.8898
73/375 [===>.....] - ETA: 0s - loss: 0.2950 - accuracy: 0.8904
90/375 [====>.....] - ETA: 0s - loss: 0.2949 - accuracy: 0.8908
108/375 [=====>.....] - ETA: 0s - loss: 0.2951 - accuracy: 0.8911
125/375 [=====>.....] - ETA: 0s - loss: 0.2953 - accuracy: 0.8915
144/375 [=====>.....] - ETA: 0s - loss: 0.2954 - accuracy: 0.8918
161/375 [=====>.....] - ETA: 0s - loss: 0.2957 - accuracy: 0.8921
179/375 [=====>.....] - ETA: 0s - loss: 0.2960 - accuracy: 0.8923
197/375 [=====>.....] - ETA: 0s - loss: 0.2963 - accuracy: 0.8925
215/375 [=====>.....] - ETA: 0s - loss: 0.2967 - accuracy: 0.8925
232/375 [=====>.....] - ETA: 0s - loss: 0.2971 - accuracy: 0.8925
248/375 [=====>.....] - ETA: 0s - loss: 0.2974 - accuracy: 0.8924
265/375 [=====>.....] - ETA: 0s - loss: 0.2979 - accuracy: 0.8924
282/375 [=====>.....] - ETA: 0s - loss: 0.2982 - accuracy: 0.8923
299/375 [=====>.....] - ETA: 0s - loss: 0.2986 - accuracy: 0.8923
315/375 [=====>.....] - ETA: 0s - loss: 0.2989 - accuracy: 0.8922
333/375 [=====>....] - ETA: 0s - loss: 0.2992 - accuracy: 0.8921
352/375 [=====>..] - ETA: 0s - loss: 0.2995 - accuracy: 0.8921
370/375 [=====>.] - ETA: 0s - loss: 0.2998 - accuracy: 0.8920
375/375 [=====] - 1s 3ms/step - loss: 0.2999 - accuracy: 0.8920
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.2999 - accuracy: 0.8920 - val_loss: 0.3553 - val_accuracy: 0.8854
Epoch 23/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.3083 - accuracy: 0.8438
```

```
21/375 [>.....] - ETA: 0s - loss: 0.3202 - accuracy: 0.8767
40/375 [==>.....] - ETA: 0s - loss: 0.3168 - accuracy: 0.8814
59/375 [===>.....] - ETA: 0s - loss: 0.3142 - accuracy: 0.8838
77/375 [====>.....] - ETA: 0s - loss: 0.3121 - accuracy: 0.8856
94/375 [=====>.....] - ETA: 0s - loss: 0.3109 - accuracy: 0.8866
108/375 [=====>.....] - ETA: 0s - loss: 0.3096 - accuracy: 0.8872
125/375 [=====>.....] - ETA: 0s - loss: 0.3081 - accuracy: 0.8880
142/375 [=====>.....] - ETA: 0s - loss: 0.3069 - accuracy: 0.8885
158/375 [=====>.....] - ETA: 0s - loss: 0.3060 - accuracy: 0.8889
174/375 [=====>.....] - ETA: 0s - loss: 0.3052 - accuracy: 0.8892
190/375 [=====>.....] - ETA: 0s - loss: 0.3045 - accuracy: 0.8896
208/375 [=====>.....] - ETA: 0s - loss: 0.3039 - accuracy: 0.8899
224/375 [=====>.....] - ETA: 0s - loss: 0.3035 - accuracy: 0.8901
240/375 [=====>.....] - ETA: 0s - loss: 0.3033 - accuracy: 0.8903
256/375 [=====>.....] - ETA: 0s - loss: 0.3030 - accuracy: 0.8905
273/375 [=====>.....] - ETA: 0s - loss: 0.3028 - accuracy: 0.8906
289/375 [=====>.....] - ETA: 0s - loss: 0.3025 - accuracy: 0.8907
306/375 [=====>.....] - ETA: 0s - loss: 0.3023 - accuracy: 0.8908
323/375 [=====>.....] - ETA: 0s - loss: 0.3022 - accuracy: 0.8909
340/375 [=====>...] - ETA: 0s - loss: 0.3021 - accuracy: 0.8910
357/375 [=====>..] - ETA: 0s - loss: 0.3021 - accuracy: 0.8911
374/375 [=====>.] - ETA: 0s - loss: 0.3020 - accuracy: 0.8912
375/375 [=====] - 1s 3ms/step - loss: 0.3020 - accuracy: 0.8912

375/375 [=====] - 1s 3ms/step - loss: 0.3020 - accuracy: 0.8912 - val_loss: 0.3531 - val_accuracy: 0.8886
Epoch 24/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2894 - accuracy: 0.8750
18/375 [>.....] - ETA: 1s - loss: 0.2833 - accuracy: 0.8885
35/375 [=>.....] - ETA: 1s - loss: 0.2797 - accuracy: 0.8929
52/375 [==>.....] - ETA: 0s - loss: 0.2822 - accuracy: 0.8925
72/375 [===>.....] - ETA: 0s - loss: 0.2859 - accuracy: 0.8918
91/375 [====>.....] - ETA: 0s - loss: 0.2868 - accuracy: 0.8918
107/375 [=====>.....] - ETA: 0s - loss: 0.2876 - accuracy: 0.8917
123/375 [=====>.....] - ETA: 0s - loss: 0.2885 - accuracy: 0.8917
140/375 [=====>.....] - ETA: 0s - loss: 0.2894 - accuracy: 0.8917
158/375 [=====>.....] - ETA: 0s - loss: 0.2904 - accuracy: 0.8917
176/375 [=====>.....] - ETA: 0s - loss: 0.2913 - accuracy: 0.8918
194/375 [=====>.....] - ETA: 0s - loss: 0.2921 - accuracy: 0.8918
213/375 [=====>.....] - ETA: 0s - loss: 0.2928 - accuracy: 0.8918
232/375 [=====>.....] - ETA: 0s - loss: 0.2935 - accuracy: 0.8918
250/375 [=====>.....] - ETA: 0s - loss: 0.2941 - accuracy: 0.8917
268/375 [=====>.....] - ETA: 0s - loss: 0.2946 - accuracy: 0.8916
286/375 [=====>.....] - ETA: 0s - loss: 0.2951 - accuracy: 0.8916
306/375 [=====>.....] - ETA: 0s - loss: 0.2956 - accuracy: 0.8916
```

```
321/375 [=====>.....] - ETA: 0s - loss: 0.2960 - accuracy: 0.8915
337/375 [=====>....] - ETA: 0s - loss: 0.2963 - accuracy: 0.8915
351/375 [=====>..] - ETA: 0s - loss: 0.2965 - accuracy: 0.8915
368/375 [=====>.] - ETA: 0s - loss: 0.2968 - accuracy: 0.8915
375/375 [=====] - 1s 3ms/step - loss: 0.2969 - accuracy: 0.8915
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.2969 - accuracy: 0.8915 - val_loss: 0.3467 - val_accuracy: 0.8911
Epoch 25/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2159 - accuracy: 0.9297
19/375 [>.....] - ETA: 1s - loss: 0.3029 - accuracy: 0.8990
38/375 [==>.....] - ETA: 0s - loss: 0.3014 - accuracy: 0.8970
57/375 [===>.....] - ETA: 0s - loss: 0.3028 - accuracy: 0.8955
74/375 [====>.....] - ETA: 0s - loss: 0.3042 - accuracy: 0.8946
93/375 [=====>.....] - ETA: 0s - loss: 0.3046 - accuracy: 0.8940
111/375 [=====>.....] - ETA: 0s - loss: 0.3043 - accuracy: 0.8938
128/375 [=====>.....] - ETA: 0s - loss: 0.3039 - accuracy: 0.8937
145/375 [=====>.....] - ETA: 0s - loss: 0.3036 - accuracy: 0.8937
164/375 [=====>.....] - ETA: 0s - loss: 0.3031 - accuracy: 0.8938
184/375 [=====>.....] - ETA: 0s - loss: 0.3028 - accuracy: 0.8939
201/375 [=====>.....] - ETA: 0s - loss: 0.3026 - accuracy: 0.8940
218/375 [=====>.....] - ETA: 0s - loss: 0.3025 - accuracy: 0.8940
237/375 [=====>.....] - ETA: 0s - loss: 0.3025 - accuracy: 0.8940
254/375 [=====>.....] - ETA: 0s - loss: 0.3024 - accuracy: 0.8940
272/375 [=====>.....] - ETA: 0s - loss: 0.3024 - accuracy: 0.8940
290/375 [=====>.....] - ETA: 0s - loss: 0.3023 - accuracy: 0.8940
309/375 [=====>.....] - ETA: 0s - loss: 0.3023 - accuracy: 0.8940
325/375 [=====>....] - ETA: 0s - loss: 0.3023 - accuracy: 0.8940
340/375 [=====>...] - ETA: 0s - loss: 0.3023 - accuracy: 0.8940
358/375 [=====>..] - ETA: 0s - loss: 0.3024 - accuracy: 0.8940
375/375 [=====] - 1s 3ms/step - loss: 0.3025 - accuracy: 0.8939
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.3025 - accuracy: 0.8939 - val_loss: 0.3567 - val_accuracy: 0.8903
Epoch 26/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2619 - accuracy: 0.9219
19/375 [>.....] - ETA: 1s - loss: 0.2833 - accuracy: 0.8964
38/375 [==>.....] - ETA: 0s - loss: 0.2851 - accuracy: 0.8954
56/375 [===>.....] - ETA: 0s - loss: 0.2906 - accuracy: 0.8941
72/375 [====>.....] - ETA: 0s - loss: 0.2924 - accuracy: 0.8941
89/375 [=====>.....] - ETA: 0s - loss: 0.2930 - accuracy: 0.8941
106/375 [=====>.....] - ETA: 0s - loss: 0.2932 - accuracy: 0.8942
124/375 [=====>.....] - ETA: 0s - loss: 0.2932 - accuracy: 0.8944
```

```
142/375 [=====>.....] - ETA: 0s - loss: 0.2933 - accuracy: 0.8947
160/375 [=====>.....] - ETA: 0s - loss: 0.2932 - accuracy: 0.8949
178/375 [=====>.....] - ETA: 0s - loss: 0.2933 - accuracy: 0.8950
196/375 [=====>.....] - ETA: 0s - loss: 0.2932 - accuracy: 0.8951
214/375 [=====>.....] - ETA: 0s - loss: 0.2931 - accuracy: 0.8952
233/375 [=====>.....] - ETA: 0s - loss: 0.2930 - accuracy: 0.8952
251/375 [=====>.....] - ETA: 0s - loss: 0.2930 - accuracy: 0.8952
268/375 [=====>.....] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
285/375 [=====>.....] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
302/375 [=====>.....] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
319/375 [=====>.....] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
336/375 [=====>....] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
354/375 [=====>..] - ETA: 0s - loss: 0.2929 - accuracy: 0.8952
373/375 [=====>.] - ETA: 0s - loss: 0.2930 - accuracy: 0.8952
375/375 [=====] - 1s 3ms/step - loss: 0.2930 - accuracy: 0.8952
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.2930 - accuracy: 0.8952 - val_loss: 0.3418 - val_accuracy: 0.8939
Epoch 27/30
```

```
1/375 [.....] - ETA: 1s - loss: 0.2746 - accuracy: 0.8984
18/375 [>.....] - ETA: 1s - loss: 0.3080 - accuracy: 0.8955
36/375 [=.....] - ETA: 0s - loss: 0.3062 - accuracy: 0.8938
55/375 [==>.....] - ETA: 0s - loss: 0.3058 - accuracy: 0.8928
72/375 [===>.....] - ETA: 0s - loss: 0.3041 - accuracy: 0.8927
89/375 [====>.....] - ETA: 0s - loss: 0.3033 - accuracy: 0.8925
106/375 [=====>.....] - ETA: 0s - loss: 0.3023 - accuracy: 0.8924
123/375 [=====>.....] - ETA: 0s - loss: 0.3015 - accuracy: 0.8925
139/375 [=====>.....] - ETA: 0s - loss: 0.3011 - accuracy: 0.8923
156/375 [=====>.....] - ETA: 0s - loss: 0.3006 - accuracy: 0.8923
172/375 [=====>.....] - ETA: 0s - loss: 0.3001 - accuracy: 0.8922
187/375 [=====>.....] - ETA: 0s - loss: 0.2997 - accuracy: 0.8922
197/375 [=====>.....] - ETA: 0s - loss: 0.2993 - accuracy: 0.8923
212/375 [=====>.....] - ETA: 0s - loss: 0.2990 - accuracy: 0.8923
229/375 [=====>.....] - ETA: 0s - loss: 0.2988 - accuracy: 0.8923
246/375 [=====>.....] - ETA: 0s - loss: 0.2985 - accuracy: 0.8923
263/375 [=====>.....] - ETA: 0s - loss: 0.2983 - accuracy: 0.8924
279/375 [=====>.....] - ETA: 0s - loss: 0.2981 - accuracy: 0.8924
294/375 [=====>.....] - ETA: 0s - loss: 0.2979 - accuracy: 0.8924
310/375 [=====>.....] - ETA: 0s - loss: 0.2976 - accuracy: 0.8925
327/375 [=====>....] - ETA: 0s - loss: 0.2974 - accuracy: 0.8926
344/375 [=====>...] - ETA: 0s - loss: 0.2973 - accuracy: 0.8926
360/375 [=====>..] - ETA: 0s - loss: 0.2973 - accuracy: 0.8926
375/375 [=====] - 1s 3ms/step - loss: 0.2972 - accuracy: 0.8927
```

```
375/375 [=====] - 1s 4ms/step - loss: 0.2972 - accuracy: 0.8
927 - val_loss: 0.3530 - val_accuracy: 0.8904
Epoch 28/30
```

```
 1/375 [.....] - ETA: 1s - loss: 0.4568 - accuracy: 0.8906
19/375 [>.....] - ETA: 1s - loss: 0.3424 - accuracy: 0.8894
37/375 [= >.....] - ETA: 0s - loss: 0.3227 - accuracy: 0.8921
55/375 [== >.....] - ETA: 0s - loss: 0.3148 - accuracy: 0.8934
71/375 [=== >.....] - ETA: 0s - loss: 0.3109 - accuracy: 0.8936
88/375 [==== >.....] - ETA: 0s - loss: 0.3081 - accuracy: 0.8939
106/375 [===== >.....] - ETA: 0s - loss: 0.3055 - accuracy: 0.8943
124/375 [===== >.....] - ETA: 0s - loss: 0.3037 - accuracy: 0.8945
140/375 [===== >.....] - ETA: 0s - loss: 0.3027 - accuracy: 0.8947
156/375 [===== >.....] - ETA: 0s - loss: 0.3016 - accuracy: 0.8948
173/375 [===== >.....] - ETA: 0s - loss: 0.3008 - accuracy: 0.8949
191/375 [===== >.....] - ETA: 0s - loss: 0.3000 - accuracy: 0.8949
210/375 [===== >.....] - ETA: 0s - loss: 0.2994 - accuracy: 0.8950
227/375 [===== >.....] - ETA: 0s - loss: 0.2991 - accuracy: 0.8949
244/375 [===== >.....] - ETA: 0s - loss: 0.2989 - accuracy: 0.8949
261/375 [===== >.....] - ETA: 0s - loss: 0.2986 - accuracy: 0.8949
277/375 [===== >.....] - ETA: 0s - loss: 0.2984 - accuracy: 0.8949
294/375 [===== >.....] - ETA: 0s - loss: 0.2983 - accuracy: 0.8948
311/375 [===== >.....] - ETA: 0s - loss: 0.2981 - accuracy: 0.8948
329/375 [===== >.....] - ETA: 0s - loss: 0.2979 - accuracy: 0.8947
345/375 [===== >...] - ETA: 0s - loss: 0.2978 - accuracy: 0.8947
362/375 [===== >..] - ETA: 0s - loss: 0.2977 - accuracy: 0.8947
373/375 [===== >.] - ETA: 0s - loss: 0.2976 - accuracy: 0.8947
375/375 [=====] - 1s 3ms/step - loss: 0.2976 - accuracy: 0.8
947
```

```
375/375 [=====] - 1s 3ms/step - loss: 0.2976 - accuracy: 0.8
947 - val_loss: 0.3508 - val_accuracy: 0.8916
Epoch 29/30
```

```
 1/375 [.....] - ETA: 1s - loss: 0.3507 - accuracy: 0.8828
16/375 [>.....] - ETA: 1s - loss: 0.2745 - accuracy: 0.9046
30/375 [= >.....] - ETA: 1s - loss: 0.2843 - accuracy: 0.8999
48/375 [== >.....] - ETA: 1s - loss: 0.2864 - accuracy: 0.8983
66/375 [=== >.....] - ETA: 0s - loss: 0.2880 - accuracy: 0.8976
81/375 [==== >.....] - ETA: 0s - loss: 0.2895 - accuracy: 0.8973
98/375 [===== >.....] - ETA: 0s - loss: 0.2901 - accuracy: 0.8973
113/375 [===== >.....] - ETA: 0s - loss: 0.2904 - accuracy: 0.8973
131/375 [===== >.....] - ETA: 0s - loss: 0.2909 - accuracy: 0.8974
148/375 [===== >.....] - ETA: 0s - loss: 0.2910 - accuracy: 0.8975
165/375 [===== >.....] - ETA: 0s - loss: 0.2912 - accuracy: 0.8977
182/375 [===== >.....] - ETA: 0s - loss: 0.2910 - accuracy: 0.8978
199/375 [===== >.....] - ETA: 0s - loss: 0.2908 - accuracy: 0.8980
```

```

217/375 [=====>.....] - ETA: 0s - loss: 0.2906 - accuracy: 0.8981
235/375 [=====>.....] - ETA: 0s - loss: 0.2905 - accuracy: 0.8983
252/375 [=====>.....] - ETA: 0s - loss: 0.2904 - accuracy: 0.8984
269/375 [=====>.....] - ETA: 0s - loss: 0.2905 - accuracy: 0.8984
284/375 [=====>.....] - ETA: 0s - loss: 0.2906 - accuracy: 0.8983
299/375 [=====>.....] - ETA: 0s - loss: 0.2907 - accuracy: 0.8983
317/375 [=====>.....] - ETA: 0s - loss: 0.2909 - accuracy: 0.8982
334/375 [=====>....] - ETA: 0s - loss: 0.2912 - accuracy: 0.8981
350/375 [=====>..] - ETA: 0s - loss: 0.2914 - accuracy: 0.8980
367/375 [=====>.] - ETA: 0s - loss: 0.2915 - accuracy: 0.8979
375/375 [=====] - 1s 3ms/step - loss: 0.2916 - accuracy: 0.8
979

```

```

375/375 [=====] - 1s 4ms/step - loss: 0.2916 - accuracy: 0.8
979 - val_loss: 0.3783 - val_accuracy: 0.8938
Epoch 30/30

```

```

  1/375 [.....] - ETA: 1s - loss: 0.2396 - accuracy: 0.9141
18/375 [>.....] - ETA: 1s - loss: 0.2727 - accuracy: 0.9007
35/375 [=>.....] - ETA: 1s - loss: 0.2806 - accuracy: 0.8988
53/375 [==>.....] - ETA: 0s - loss: 0.2825 - accuracy: 0.8984
71/375 [===>.....] - ETA: 0s - loss: 0.2827 - accuracy: 0.8982
88/375 [====>.....] - ETA: 0s - loss: 0.2828 - accuracy: 0.8980
106/375 [=====>.....] - ETA: 0s - loss: 0.2837 - accuracy: 0.8977
124/375 [=====>.....] - ETA: 0s - loss: 0.2843 - accuracy: 0.8974
141/375 [=====>.....] - ETA: 0s - loss: 0.2849 - accuracy: 0.8971
159/375 [=====>.....] - ETA: 0s - loss: 0.2854 - accuracy: 0.8969
177/375 [=====>.....] - ETA: 0s - loss: 0.2858 - accuracy: 0.8968
194/375 [=====>.....] - ETA: 0s - loss: 0.2861 - accuracy: 0.8968
210/375 [=====>.....] - ETA: 0s - loss: 0.2863 - accuracy: 0.8967
223/375 [=====>.....] - ETA: 0s - loss: 0.2865 - accuracy: 0.8967
238/375 [=====>.....] - ETA: 0s - loss: 0.2867 - accuracy: 0.8966
255/375 [=====>.....] - ETA: 0s - loss: 0.2870 - accuracy: 0.8966
272/375 [=====>.....] - ETA: 0s - loss: 0.2873 - accuracy: 0.8965
288/375 [=====>.....] - ETA: 0s - loss: 0.2876 - accuracy: 0.8965
305/375 [=====>.....] - ETA: 0s - loss: 0.2879 - accuracy: 0.8964
322/375 [=====>.....] - ETA: 0s - loss: 0.2881 - accuracy: 0.8964
336/375 [=====>....] - ETA: 0s - loss: 0.2883 - accuracy: 0.8963
351/375 [=====>..] - ETA: 0s - loss: 0.2885 - accuracy: 0.8963
367/375 [=====>.] - ETA: 0s - loss: 0.2887 - accuracy: 0.8963
375/375 [=====] - 1s 3ms/step - loss: 0.2887 - accuracy: 0.8
963

```

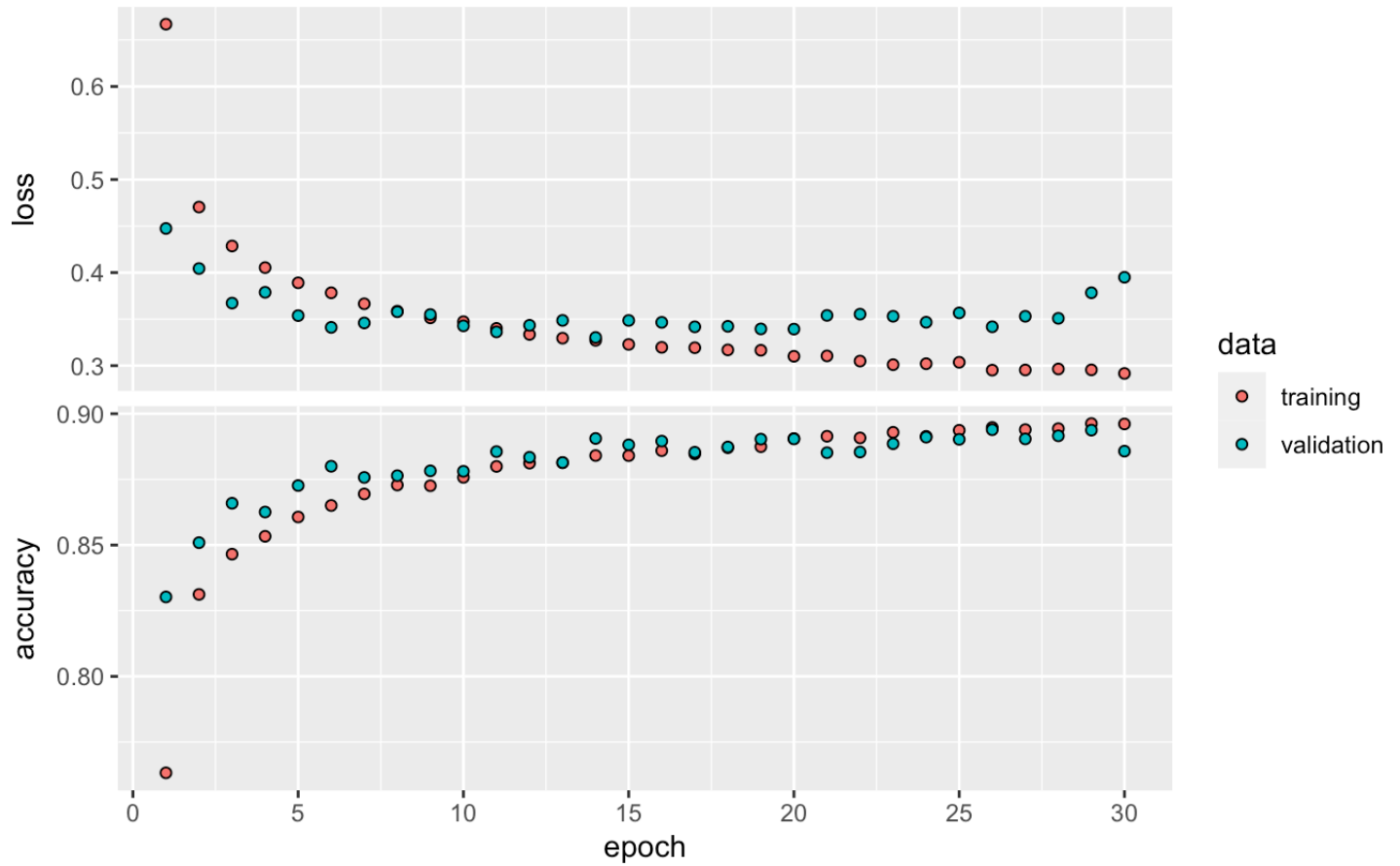
```

375/375 [=====] - 1s 4ms/step - loss: 0.2887 - accuracy: 0.8
963 - val_loss: 0.3950 - val_accuracy: 0.8857
  user system elapsed
109.641  19.130  44.629

```

Hide

```
plot(history, smooth = FALSE)
```



Hide

```
accuracy <- function(pred, truth)
  mean(drop(as.numeric(pred)) == drop(truth))
```

Hide

```
model_NN %>% predict(xx_test) %>% k_argmax() %>%
  accuracy(dat[60001:70000,785])
```

```
[1] 0.8813
```

Hide

```
xx_train <- dat[1:1000,1:784]
yy_train <- to_categorical(dat[1:1000,785])
xx_test <- dat[1001:70000,1:784]
yy_test <- to_categorical(dat[1001:70000,785])
#Rescale the grayscale images to make the pixel intensity
# on the unit interval
xx_train <- xx_train/255
# massage the data for tensorflow
xx_train<-array_reshape(as.matrix(xx_train),c(1000,784))
xx_test <- xx_test/255

# massage the data for tensorflow
xx_test<-array_reshape(as.matrix(xx_test),c(69000,784))

# Use the same network structure as used for # the MNist data from class
model_NN <- keras_model_sequential()
```

2022-04-28 20:08:39.986317: I tensorflow/core/platform/cpu_feature_guard.cc:142] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations: SSE4.1 SSE4.2 AVX AVX2 FMA

To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.

[Hide](#)

```
model_NN %>%
  layer_dense(units = 256, activation = "relu",
              input_shape = c(784)) %>%
  layer_dropout(rate = 0.4) %>%
  layer_dense(units = 128, activation = "relu") %>% layer_dropout(rate = 0.3) %>%
  layer_dense(units = 10, activation = "softmax")
summary(model_NN)
```


Model: "sequential"

Layer (type)	Output Shape	Param #
=====		
dense_2 (Dense)	(None, 256)	200960
=====		
dropout_1 (Dropout)	(None, 256)	0
=====		
dense_1 (Dense)	(None, 128)	32896
=====		
dropout (Dropout)	(None, 128)	0
=====		
dense (Dense)	(None, 10)	1290
=====		
Total params: 235,146		
Trainable params: 235,146		
Non-trainable params: 0		

[Hide](#)

```
####
model_NN %>% compile(loss = "categorical_crossentropy",
                     optimizer = optimizer_rmsprop(),
                     metrics = c("accuracy"))

####
system.time(
  history <- model_NN %>%
    fit(xx_train, yy_train, epochs = 30, batch_size = 128,
        validation_split = 0.2)
)
```

```
2022-04-28 20:08:40.637613: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.c
c:116] None of the MLIR optimization passes are enabled (registered 2)
```

Epoch 1/30

1/7 [==>.....] - ETA: 2s - loss: 2.3603 - accuracy: 0.1016
7/7 [=====] - 1s 5ms/step - loss: 2.0033 - accuracy: 0.2807

7/7 [=====] - 1s 93ms/step - loss: 1.9769 - accuracy: 0.2922
- val_loss: 1.4308 - val_accuracy: 0.4400

Epoch 2/30

1/7 [==>.....] - ETA: 0s - loss: 1.5969 - accuracy: 0.3984
7/7 [=====] - 0s 3ms/step - loss: 1.3939 - accuracy: 0.4822

7/7 [=====] - 0s 5ms/step - loss: 1.3841 - accuracy: 0.4874
- val_loss: 1.1388 - val_accuracy: 0.6150

Epoch 3/30

1/7 [==>.....] - ETA: 0s - loss: 1.6447 - accuracy: 0.4766
7/7 [=====] - 0s 4ms/step - loss: 1.2658 - accuracy: 0.5855

7/7 [=====] - 0s 7ms/step - loss: 1.2518 - accuracy: 0.5883
- val_loss: 0.8833 - val_accuracy: 0.6700

Epoch 4/30

1/7 [==>.....] - ETA: 0s - loss: 0.9609 - accuracy: 0.6719
7/7 [=====] - 0s 3ms/step - loss: 1.0392 - accuracy: 0.6376

7/7 [=====] - 0s 7ms/step - loss: 1.0382 - accuracy: 0.6382
- val_loss: 0.8563 - val_accuracy: 0.6750

Epoch 5/30

1/7 [==>.....] - ETA: 0s - loss: 0.8684 - accuracy: 0.7266
7/7 [=====] - 0s 3ms/step - loss: 0.8957 - accuracy: 0.6992

7/7 [=====] - 0s 6ms/step - loss: 0.8985 - accuracy: 0.6971
- val_loss: 0.7504 - val_accuracy: 0.7450

Epoch 6/30

1/7 [==>.....] - ETA: 0s - loss: 0.8646 - accuracy: 0.7266
7/7 [=====] - 0s 3ms/step - loss: 0.8747 - accuracy: 0.7027

7/7 [=====] - 0s 7ms/step - loss: 0.8748 - accuracy: 0.7012
- val_loss: 0.8828 - val_accuracy: 0.6700

Epoch 7/30

1/7 [==>.....] - ETA: 0s - loss: 0.9046 - accuracy: 0.6797
7/7 [=====] - 0s 4ms/step - loss: 0.8349 - accuracy: 0.7004

```
7/7 [=====] - 0s 7ms/step - loss: 0.8308 - accuracy: 0.7021
- val_loss: 0.6818 - val_accuracy: 0.7600
Epoch 8/30

1/7 [==>.....] - ETA: 0s - loss: 0.7117 - accuracy: 0.7656
7/7 [=====] - 0s 2ms/step - loss: 0.7297 - accuracy: 0.7563

7/7 [=====] - 0s 5ms/step - loss: 0.7292 - accuracy: 0.7566
- val_loss: 0.6657 - val_accuracy: 0.7150
Epoch 9/30

1/7 [==>.....] - ETA: 0s - loss: 0.7854 - accuracy: 0.7031
7/7 [=====] - 0s 2ms/step - loss: 0.7374 - accuracy: 0.7308

7/7 [=====] - 0s 5ms/step - loss: 0.7360 - accuracy: 0.7316
- val_loss: 0.6378 - val_accuracy: 0.7750
Epoch 10/30

1/7 [==>.....] - ETA: 0s - loss: 0.7869 - accuracy: 0.7422
7/7 [=====] - 0s 3ms/step - loss: 0.7200 - accuracy: 0.7544

7/7 [=====] - 0s 5ms/step - loss: 0.7172 - accuracy: 0.7549
- val_loss: 0.7172 - val_accuracy: 0.7650
Epoch 11/30

1/7 [==>.....] - ETA: 0s - loss: 0.7808 - accuracy: 0.7031
7/7 [=====] - 0s 3ms/step - loss: 0.6978 - accuracy: 0.7650

7/7 [=====] - 0s 6ms/step - loss: 0.6965 - accuracy: 0.7663
- val_loss: 0.5779 - val_accuracy: 0.8250
Epoch 12/30

1/7 [==>.....] - ETA: 0s - loss: 0.6827 - accuracy: 0.7812
7/7 [=====] - 0s 4ms/step - loss: 0.6366 - accuracy: 0.7881

7/7 [=====] - 0s 6ms/step - loss: 0.6371 - accuracy: 0.7871
- val_loss: 0.6668 - val_accuracy: 0.7750
Epoch 13/30

1/7 [==>.....] - ETA: 0s - loss: 0.7153 - accuracy: 0.7500
7/7 [=====] - 0s 4ms/step - loss: 0.6378 - accuracy: 0.7803

7/7 [=====] - 0s 7ms/step - loss: 0.6347 - accuracy: 0.7812
- val_loss: 0.6857 - val_accuracy: 0.7350
Epoch 14/30

1/7 [==>.....] - ETA: 0s - loss: 0.6498 - accuracy: 0.7734
```

```
7/7 [=====] - 0s 4ms/step - loss: 0.5602 - accuracy: 0.8087

7/7 [=====] - 0s 7ms/step - loss: 0.5612 - accuracy: 0.8087
- val_loss: 0.7329 - val_accuracy: 0.7300
Epoch 15/30

1/7 [==>.....] - ETA: 0s - loss: 0.8197 - accuracy: 0.7500
7/7 [=====] - 0s 5ms/step - loss: 0.6474 - accuracy: 0.7847

7/7 [=====] - 0s 8ms/step - loss: 0.6425 - accuracy: 0.7850
- val_loss: 0.5814 - val_accuracy: 0.8100
Epoch 16/30

1/7 [==>.....] - ETA: 0s - loss: 0.6956 - accuracy: 0.7656
7/7 [=====] - 0s 2ms/step - loss: 0.5809 - accuracy: 0.8092

7/7 [=====] - 0s 5ms/step - loss: 0.5758 - accuracy: 0.8110
- val_loss: 0.5908 - val_accuracy: 0.7850
Epoch 17/30

1/7 [==>.....] - ETA: 0s - loss: 0.6485 - accuracy: 0.7969
7/7 [=====] - 0s 3ms/step - loss: 0.5871 - accuracy: 0.8124

7/7 [=====] - 0s 5ms/step - loss: 0.5816 - accuracy: 0.8137
- val_loss: 0.5397 - val_accuracy: 0.8250
Epoch 18/30

1/7 [==>.....] - ETA: 0s - loss: 0.4894 - accuracy: 0.8125
7/7 [=====] - 0s 4ms/step - loss: 0.4617 - accuracy: 0.8309

7/7 [=====] - 0s 7ms/step - loss: 0.4602 - accuracy: 0.8323
- val_loss: 0.6008 - val_accuracy: 0.8350
Epoch 19/30

1/7 [==>.....] - ETA: 0s - loss: 0.8107 - accuracy: 0.7266
7/7 [=====] - 0s 4ms/step - loss: 0.6239 - accuracy: 0.7830

7/7 [=====] - 0s 7ms/step - loss: 0.6131 - accuracy: 0.7872
- val_loss: 0.5429 - val_accuracy: 0.8050
Epoch 20/30

1/7 [==>.....] - ETA: 0s - loss: 0.4445 - accuracy: 0.8359
7/7 [=====] - 0s 6ms/step - loss: 0.4675 - accuracy: 0.8442

7/7 [=====] - 0s 8ms/step - loss: 0.4669 - accuracy: 0.8451
- val_loss: 0.6188 - val_accuracy: 0.7850
Epoch 21/30
```

```
1/7 [==>.....] - ETA: 0s - loss: 0.4391 - accuracy: 0.8672
7/7 [=====] - 0s 4ms/step - loss: 0.4506 - accuracy: 0.8533

7/7 [=====] - 0s 7ms/step - loss: 0.4515 - accuracy: 0.8527
- val_loss: 0.5970 - val_accuracy: 0.8000
Epoch 22/30

1/7 [==>.....] - ETA: 0s - loss: 0.5463 - accuracy: 0.8125
7/7 [=====] - 0s 3ms/step - loss: 0.5059 - accuracy: 0.8239

7/7 [=====] - 0s 5ms/step - loss: 0.5057 - accuracy: 0.8241
- val_loss: 0.5420 - val_accuracy: 0.8050
Epoch 23/30

1/7 [==>.....] - ETA: 0s - loss: 0.4688 - accuracy: 0.8516
7/7 [=====] - 0s 3ms/step - loss: 0.4430 - accuracy: 0.8605

7/7 [=====] - 0s 6ms/step - loss: 0.4447 - accuracy: 0.8591
- val_loss: 0.7185 - val_accuracy: 0.7800
Epoch 24/30

1/7 [==>.....] - ETA: 0s - loss: 0.5250 - accuracy: 0.8047
7/7 [=====] - 0s 4ms/step - loss: 0.4357 - accuracy: 0.8451

7/7 [=====] - 0s 6ms/step - loss: 0.4324 - accuracy: 0.8465
- val_loss: 0.5209 - val_accuracy: 0.8000
Epoch 25/30

1/7 [==>.....] - ETA: 0s - loss: 0.3534 - accuracy: 0.9062
7/7 [=====] - 0s 5ms/step - loss: 0.3551 - accuracy: 0.8904

7/7 [=====] - 0s 7ms/step - loss: 0.3565 - accuracy: 0.8897
- val_loss: 0.5097 - val_accuracy: 0.8350
Epoch 26/30

1/7 [==>.....] - ETA: 0s - loss: 0.3843 - accuracy: 0.8828
7/7 [=====] - 0s 4ms/step - loss: 0.3940 - accuracy: 0.8742

7/7 [=====] - 0s 7ms/step - loss: 0.3928 - accuracy: 0.8744
- val_loss: 0.5208 - val_accuracy: 0.8100
Epoch 27/30

1/7 [==>.....] - ETA: 0s - loss: 0.4606 - accuracy: 0.8438
7/7 [=====] - 0s 4ms/step - loss: 0.3891 - accuracy: 0.8750

7/7 [=====] - 0s 7ms/step - loss: 0.3861 - accuracy: 0.8755
```

```

- val_loss: 0.6905 - val_accuracy: 0.7450
Epoch 28/30

1/7 [==>.....] - ETA: 0s - loss: 0.7146 - accuracy: 0.7734
7/7 [=====] - 0s 4ms/step - loss: 0.5080 - accuracy: 0.8237

7/7 [=====] - 0s 7ms/step - loss: 0.4970 - accuracy: 0.8278
- val_loss: 0.4263 - val_accuracy: 0.8550
Epoch 29/30

1/7 [==>.....] - ETA: 0s - loss: 0.3392 - accuracy: 0.9062
7/7 [=====] - 0s 4ms/step - loss: 0.3472 - accuracy: 0.8913

7/7 [=====] - 0s 8ms/step - loss: 0.3482 - accuracy: 0.8903
- val_loss: 0.5895 - val_accuracy: 0.7800
Epoch 30/30

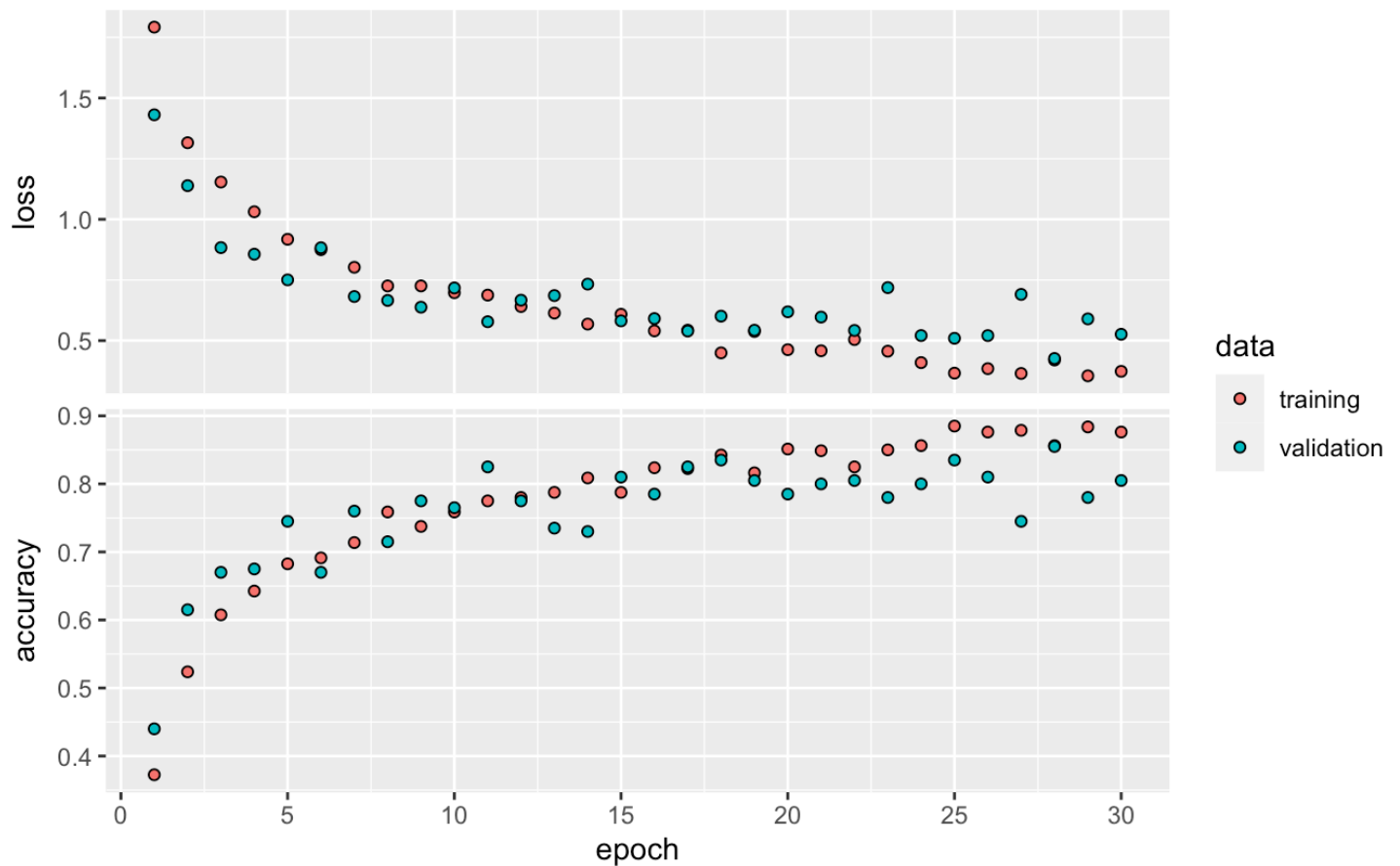
1/7 [==>.....] - ETA: 0s - loss: 0.3872 - accuracy: 0.8281
7/7 [=====] - 0s 4ms/step - loss: 0.3742 - accuracy: 0.8632

7/7 [=====] - 0s 7ms/step - loss: 0.3741 - accuracy: 0.8648
- val_loss: 0.5262 - val_accuracy: 0.8050
  user  system elapsed
 4.108   0.952   6.516

```

[Hide](#)

```
plot(history, smooth = FALSE)
```



Hide

```
accuracy <- function(pred, truth)
  mean(drop(as.numeric(pred)) == drop(truth))

model_NN %>% predict(xx_test) %>% k_argmax() %>%
  accuracy(dat[1001:70000,785])
```

```
[1] 0.7932029
```

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Cmd+Option+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Cmd+Shift+K* to preview the HTML file).

The preview shows you a rendered HTML copy of the contents of the editor. Consequently, unlike *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was last run in the editor is displayed.