HW9_Chen_Han

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Example 1

```r
# install
# install.packages("devtools")
# devtools::install_github("rstudio/keras")
library(keras)
install_keras()
```

Prapare Data

```r
library(keras)
mnist <- dataset_mnist()
x_train <- mnist$train$x
y_train <- mnist$train$y
x_test <- mnist$test$x
y_test <- mnist$test$y

# reshape
x_train <- array_reshape(x_train, c(nrow(x_train), 784))
x_test <- array_reshape(x_test, c(nrow(x_test), 784))
# rescale
x_train <- x_train / 255
x_test <- x_test / 255

y_train <- to_categorical(y_train, 10)
y_test <- to_categorical(y_test, 10)
```

Defining the Model

```r
model <- keras_model_sequential()
model %>%
  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)
```

```
## Model: "sequential"
## ___________________________________________________________________________
## Layer (type)                     Output Shape                  Param #
## ===========================================================================
## dense (Dense)                    (None, 256)                   200960
## ___________________________________________________________________________
## dropout (Dropout)                (None, 256)                   0
```

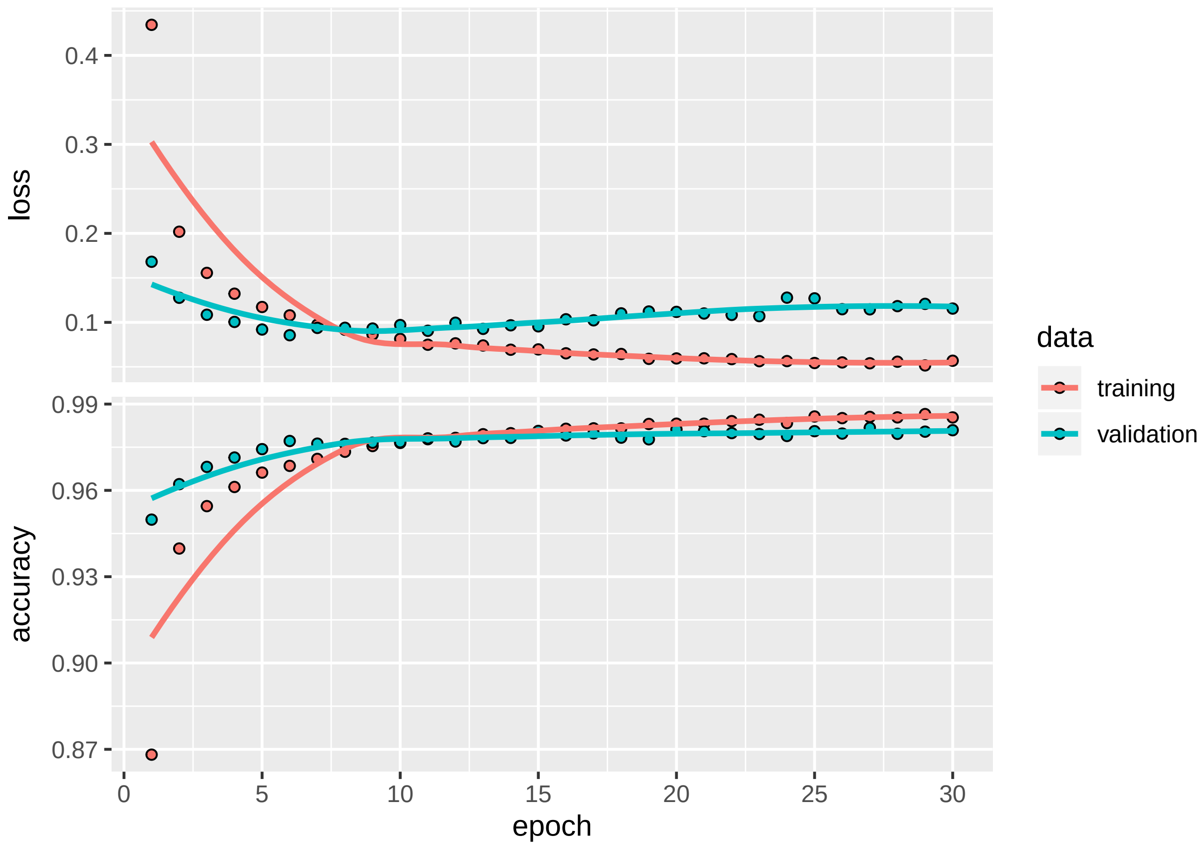
```
## ________________________________________________________________________________
## dense_1 (Dense)                  (None, 128)                   32896
## ________________________________________________________________________________
## dropout_1 (Dropout)              (None, 128)                   0
## ________________________________________________________________________________
## dense_2 (Dense)                  (None, 10)                    1290
## ================================================================================
## Total params: 235,146
## Trainable params: 235,146
## Non-trainable params: 0
## ________________________________________________________________________________
```

```r
model %>% compile(
  loss = 'categorical_crossentropy',
  optimizer = optimizer_rmsprop(),
  metrics = c('accuracy')
)
```

Training and Evaluation

```r
history <- model %>% fit(
  x_train, y_train,
  epochs = 30, batch_size = 128,
  validation_split = 0.2
)

plot(history)
```



```r
model %>% evaluate(x_test, y_test)
```

```
## $loss
## [1] 0.1063325
##
## $accuracy
## [1] 0.9826
```

```r
model %>% predict_classes(x_test)
```

```
##      [1] 7 2 1 0 4 1 4 9 6 9 0 6 9 0 1 5 9 7 3 4 9 6 6 5 4 0 7 4 0 1 3 1 3 4
##     [35] 7 2 7 1 2 1 1 7 4 2 3 5 1 2 4 4 6 3 5 5 6 0 4 1 9 5 7 8 9 3 7 4 6 4
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## [5883] 3 2 6 5 6 0 4 1 0 5 3 1 9 2 1 9 6 0 4 6 1 7 3 8 7 2 9 6 5 8 3 5 7 1
## [5917] 6 1 0 9 6 2 5 4 2 3 4 4 6 0 0 2 0 1 2 3 9 5 6 7 8 9 0 1 2 3 4 5 6 7
## [5951] 8 9 0 1 2 8 4 5 6 7 8 9 8 6 5 0 6 8 9 4 1 9 5 8 0 4 8 9 1 4 0 5 5 2
## [5985] 1 5 4 0 7 6 0 1 7 0 6 8 9 5 1 7 9 8 6 0 8 1 7 7 1 3 2 0 1 4 2 0 0 7
## [6019] 8 4 6 4 9 3 8 4 7 2 5 6 3 6 9 6 3 2 2 4 6 9 0 2 5 5 1 3 3 9 7 8 7 2
## [6053] 2 5 7 9 8 2 1 3 1 3 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
## [6087] 4 5 6 7 8 9 1 2 6 5 3 0 7 0 4 1 4 3 6 7 2 3 1 2 1 2 9 6 0 1 3 0 2 7
## [6121] 5 7 6 2 9 1 9 0 6 0 6 0 2 0 6 1 5 8 4 3 0 1 5 4 4 8 5 7 5 7 8 3 4 8
## [6155] 8 5 2 9 7 1 3 8 1 0 7 5 3 6 9 4 7 7 9 9 3 4 4 3 8 6 2 0 1 2 3 4 5 6
## [6189] 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 8 3 9 5 5 2 6 8 4 9
## [6223] 1 7 1 2 3 5 9 6 9 1 1 1 2 9 5 6 8 1 2 0 7 7 5 8 2 9 8 9 0 4 6 7 1 3
## [6257] 4 5 6 0 3 6 8 7 0 4 2 7 4 7 5 4 3 4 2 8 1 5 1 2 0 2 5 6 4 3 0 0 0 3
## [6291] 3 5 7 0 6 4 8 8 6 3 4 6 9 9 8 2 7 7 1 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
## [6325] 5 6 7 8 0 1 2 3 4 5 6 7 8 2 1 7 2 5 0 8 0 2 7 8 8 3 6 0 2 7 6 6 1 2
## [6359] 8 8 7 7 4 7 7 3 7 4 5 4 3 3 8 4 1 1 9 7 4 3 7 3 3 0 2 5 5 6 6 3 5 2
## [6393] 5 9 9 8 4 1 0 6 0 9 6 8 8 5 6 1 1 9 8 9 2 3 5 5 9 4 2 1 9 2 9 2 0 6
## [6427] 0 4 0 0 1 2 3 4 7 8 9 0 1 2 3 7 8 9 0 1 2 3 4 7 8 9 7 3 0 3 1 8 7 6
## [6461] 4 0 2 6 8 3 2 8 1 2 0 7 1 0 4 4 5 8 0 6 2 3 1 5 1 8 5 9 4 0 7 5 8 8
## [6495] 3 8 9 2 6 2 5 3 1 7 3 0 1 9 9 6 0 3 9 2 8 1 4 3 5 2 9 2 5 8 9 5 0 1
## [6529] 2 4 5 6 0 1 2 3 4 5 6 7 1 2 3 4 5 1 0 4 5 6 6 3 4 4 2 9 1 0 6 4 9 7
## [6563] 2 3 3 9 2 0 4 3 3 7 1 5 6 3 1 1 8 4 0 2 4 0 2 4 7 8 0 7 0 6 9 3 2 8
## [6597] 6 7 5 7 5 1 0 8 1 6 7 2 9 7 9 5 8 6 2 6 2 8 1 7 5 0 1 1 3 4 4 9 1 8
## [6631] 6 8 5 0 1 2 3 4 5 6 7 5 9 0 1 2 3 4 7 8 9 5 1 7 8 9 9 8 9 8 4 1 7 7
## [6665] 3 3 7 6 6 6 1 9 0 1 7 6 3 2 1 7 1 3 9 1 7 6 8 4 1 4 3 6 9 6 1 4 4 7
## [6699] 2 4 4 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 9 0 1 2 3 4 7 8 1 3 5 1 7 7
## [6733] 2 1 4 8 3 4 4 3 9 7 4 1 2 3 5 9 1 6 0 1 0 0 2 9 7 1 1 4 0 4 7 3 6 8
## [6767] 0 3 7 4 0 6 9 2 6 5 8 6 9 0 4 0 6 6 9 2 0 9 5 1 3 7 6 9 3 0 2 2 0 1
## [6801] 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 2 1 7 2 5 0
## [6835] 8 0 2 7 8 8 3 0 6 0 2 7 6 6 1 2 8 8 7 7 4 7 7 3 7 4 5 4 3 3 8 4 5 4
## [6869] 1 1 9 7 4 3 7 3 3 0 2 5 5 6 3 1 5 2 5 9 9 8 4 1 0 6 0 9 6 8 8 5 6 1
## [6903] 1 9 8 9 2 3 5 5 9 4 2 1 9 4 9 1 3 9 2 0 6 0 4 0 6 0 1 2 3 4 5 6 7 8
## [6937] 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 3 8 0 7 1 0 7 5 5 6 9 0 1
## [6971] 0 0 8 3 4 3 1 5 0 0 9 5 3 4 9 3 7 6 9 2 4 5 7 2 6 4 9 4 9 4 1 2 2 5
```

```
## [7005] 8 1 3 2 9 4 3 8 2 2 1 2 8 6 5 1 6 7 2 1 3 9 3 8 7 5 7 0 7 4 8 8 5 0
## [7039] 6 6 3 7 6 9 9 4 8 4 1 0 6 6 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
## [7073] 0 1 2 3 4 5 6 7 8 9 7 4 0 4 0 1 7 9 5 1 4 2 8 9 4 3 7 8 2 4 4 3 3 6
## [7107] 9 9 5 8 6 7 0 6 8 2 6 3 9 3 2 8 6 1 7 4 8 8 9 0 3 3 9 0 5 2 9 4 1 0
## [7141] 3 7 5 8 7 7 8 2 9 7 1 2 6 4 2 5 2 3 6 6 5 0 0 2 8 1 6 1 0 4 3 1 6 1
## [7175] 9 0 1 4 5 6 7 8 9 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 8 9 8 4 0 0 7 2 4 3
## [7209] 8 6 6 3 2 6 3 3 6 1 4 7 8 0 3 1 9 0 1 9 1 2 7 0 1 3 8 2 9 2 7 6 5 5
## [7243] 9 9 8 2 9 1 3 2 3 4 3 1 9 0 9 3 6 8 7 0 1 0 5 8 2 7 7 0 1 2 3 4 5 6
## [7277] 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 1 7 4 8 1 5 6 5 7 2 8
## [7311] 6 3 3 8 6 5 4 0 9 1 7 2 9 1 5 1 3 2 2 3 0 6 4 3 7 6 9 0 4 8 1 4 0 6
## [7345] 1 2 6 9 2 2 3 5 5 1 0 7 7 9 6 2 9 4 7 0 2 3 4 0 0 8 8 8 5 1 3 7 4 9
## [7379] 8 8 9 0 9 8 9 0 2 6 5 6 7 4 7 5 4 1 3 5 3 1 2 3 4 5 6 1 2 3 4 6 0 1
## [7413] 2 4 5 6 7 8 1 7 2 4 1 4 1 4 9 6 8 4 5 3 7 8 4 3 3 5 6 7 0 6 1 6 8 7
## [7447] 0 1 5 0 8 5 0 1 5 8 4 2 3 9 7 6 9 1 9 0 6 7 1 2 3 9 2 4 5 5 3 7 5 3
## [7481] 1 8 2 2 3 0 2 9 4 9 7 0 2 7 4 9 9 2 5 9 8 3 8 6 7 0 0 1 2 3 4 5 6 7
## [7515] 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 0 7 2 6 5 5 3 7 8 6 6
## [7549] 6 6 4 3 8 8 3 0 1 9 0 5 4 1 9 1 2 7 0 1 3 8 2 9 2 7 4 2 6 5 5 9 9 1
## [7583] 1 5 7 6 8 2 9 4 3 1 9 0 9 3 6 8 7 0 1 0 5 8 2 7 7 0 1 2 3 4 5 6 7 8
## [7617] 9 0 1 2 3 4 5 8 9 0 1 2 3 4 5 6 7 8 9 2 1 2 1 3 9 9 8 5 3 7 0 7 7 5
## [7651] 7 9 9 4 7 0 3 4 1 5 8 1 4 8 4 1 8 6 6 4 6 0 5 5 3 3 5 7 2 5 9 6 9 2
## [7685] 6 2 1 2 0 8 3 8 3 0 8 7 4 9 5 0 9 7 0 0 4 6 0 9 1 6 2 7 6 8 3 5 2 1
## [7719] 8 3 8 6 1 0 2 1 4 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
## [7753] 5 6 7 8 9 7 6 4 7 6 2 3 4 8 7 8 6 9 8 3 2 2 8 4 8 5 6 5 0 2 0 1 1 2
## [7787] 9 6 8 2 1 0 6 5 2 9 7 5 3 9 3 7 1 8 3 8 1 9 5 5 0 1 1 9 8 2 6 0 4 5
## [7821] 0 3 1 8 6 7 5 9 9 3 0 3 1 4 4 0 4 9 0 1 2 3 5 6 7 8 0 1 2 3 5 6 7 8
## [7855] 9 0 1 2 3 5 6 7 8 9 9 7 0 9 0 1 5 8 8 0 9 3 2 7 8 4 6 1 0 4 9 4 2 0
## [7889] 5 0 1 6 9 3 2 9 1 6 0 1 1 8 7 7 6 3 6 0 7 2 4 1 7 0 6 7 1 2 5 8 1 2
## [7923] 2 8 7 6 8 7 0 6 2 9 3 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2
## [7957] 3 4 5 6 7 8 9 8 9 5 7 0 3 1 6 8 4 1 5 6 4 2 7 8 1 3 4 3 4 7 2 0 5 0
## [7991] 1 9 2 3 2 3 5 5 7 8 4 9 9 7 1 1 9 0 7 8 3 4 8 6 3 8 0 9 6 2 1 0 1 0
## [8025] 6 2 3 8 9 0 7 2 3 4 5 5 2 8 5 4 6 6 6 7 9 1 8 2 1 5 3 4 7 9 4 0 0 0
## [8059] 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 9 0 1 3 1 5 1 2
## [8093] 4 9 2 4 6 8 0 1 1 9 2 6 6 8 7 4 2 9 7 0 2 1 0 3 6 0 1 2 3 4 5 6 7 8
## [8127] 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 8 6 5 9 7 0 2 3 4 3 8 5 1
## [8161] 5 2 3 0 1 2 1 3 2 6 5 3 0 7 2 7 4 6 4 0 5 9 9 8 9 5 3 1 7 4 7 6 5 4
## [8195] 0 0 6 6 2 0 6 3 7 7 4 4 3 9 2 8 9 6 0 9 5 3 8 8 7 1 4 0 4 8 5 2 3 9
## [8229] 0 1 9 1 5 1 7 4 8 6 2 1 6 8 8 0 1 2 3 4 7 8 9 0 1 2 3 4 6 7 8 9 0 1
## [8263] 2 3 4 7 8 9 1 4 5 3 3 0 9 5 4 9 0 8 4 6 7 0 7 7 1 6 9 1 3 6 2 3 8 2
## [8297] 3 8 9 5 8 8 7 1 7 1 1 0 3 4 2 6 4 7 4 2 7 4 2 9 2 7 9 2 1 6 6 5 3 4
## [8331] 8 5 9 6 9 0 6 3 0 8 1 6 0 0 1 2 3 4 5 6 7 0 1 2 3 4 7 8 9 0 1 2 3 4
## [8365] 7 2 5 1 6 4 3 9 9 0 9 7 1 6 4 3 6 2 0 9 8 6 5 7 0 0 1 7 4 3 2 4 1 3
## [8399] 7 6 4 7 7 7 9 8 4 3 5 2 8 3 5 8 0 5 4 7 1 3 1 7 9 6 2 0 9 1 7 3 3 9
## [8433] 1 6 4 3 9 8 2 1 8 6 4 1 5 5 6 5 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7
## [8467] 8 9 0 1 2 3 4 5 6 7 8 9 6 9 7 0 2 3 4 3 8 5 1 3 0 1 2 1 3 2 0 7 2 6
## [8501] 4 0 5 9 9 8 9 5 3 1 7 4 7 0 0 6 6 6 3 7 4 2 8 9 8 7 1 9 0 4 8 5 2 3
## [8535] 9 0 1 9 1 5 1 7 6 1 2 1 6 8 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 0
## [8569] 1 2 3 5 6 7 8 1 0 4 5 6 6 3 4 4 2 8 1 0 6 4 9 7 2 9 2 0 9 3 3 9 1 5
## [8603] 2 3 1 6 7 3 7 8 4 0 2 4 0 2 4 7 8 0 7 0 6 9 3 2 4 8 6 0 5 7 5 1 0 8
## [8637] 1 6 7 2 9 7 9 5 6 5 2 6 2 8 1 7 5 5 7 3 5 0 1 1 3 8 4 9 4 5 1 8 6 8
## [8671] 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 3 5 3
## [8705] 2 9 3 2 1 4 5 5 2 3 2 1 3 9 7 2 1 2 8 9 1 8 8 7 8 1 0 0 6 7 7 8 7 5
## [8739] 0 6 1 5 7 4 6 1 2 5 0 7 9 9 0 3 4 4 8 4 1 8 6 5 9 0 0 0 3 7 1 6 4 6
## [8773] 0 4 5 4 1 3 8 6 3 9 9 5 9 3 7 8 5 6 4 7 6 2 2 0 9 4 0 1 2 3 4 5 6 7
## [8807] 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 6 4 2 6 4 7 5 5 4 7 2 9
```

```
## [8841] 3 9 3 8 2 0 9 5 6 0 1 0 6 5 3 5 3 8 0 0 3 4 1 5 3 0 8 3 0 6 2 7 8 1
## [8875] 7 1 3 8 5 4 2 0 9 7 6 7 4 1 6 2 6 7 1 9 8 0 6 9 4 9 9 6 2 3 7 1 9 2
## [8909] 2 5 3 7 8 0 1 2 3 4 7 8 9 0 1 2 3 4 7 8 9 0 1 7 8 9 8 9 2 6 1 3 5 4
## [8943] 8 2 6 4 3 4 5 9 2 0 3 9 4 9 7 3 8 7 4 4 9 8 5 8 2 6 6 2 3 1 3 2 7 3
## [8977] 1 9 0 1 1 3 5 0 7 8 1 5 1 4 6 0 0 4 9 1 6 6 9 0 7 6 1 1 0 1 2 3 4 2
## [9011] 2 3 4 5 6 2 0 1 2 2 8 6 3 9 2 1 9 3 9 6 1 7 2 4 4 5 7 0 0 1 6 6 8 2
## [9045] 7 7 2 4 2 1 6 1 0 6 9 8 3 9 6 3 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7
## [9079] 8 9 0 1 2 3 4 5 6 7 8 9 1 6 8 9 9 0 1 2 4 4 3 7 4 4 4 0 3 8 7 5 8 2
## [9113] 1 7 5 3 8 5 2 5 1 1 6 2 1 3 8 6 4 2 6 2 5 5 0 2 8 0 6 8 1 7 9 1 9 2
## [9147] 6 7 6 6 8 7 4 9 2 1 3 3 0 5 5 8 0 3 7 9 7 0 2 7 9 1 7 8 0 3 5 3 6 0
## [9181] 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 7 8 9 6 4 2 6 4 7 8
## [9215] 9 2 9 3 9 3 0 0 1 0 4 2 6 3 5 3 0 3 4 1 5 3 0 8 3 0 6 1 7 8 0 9 2 6
## [9249] 7 1 9 6 9 4 9 9 6 7 1 2 5 3 7 8 0 1 2 4 5 6 7 8 9 0 1 3 4 5 6 7 5 0
## [9283] 1 3 4 7 8 9 7 5 5 1 9 9 7 1 0 0 5 9 7 1 7 2 2 3 6 8 3 2 0 0 6 1 7 5
## [9317] 8 6 2 9 4 8 8 7 1 0 8 7 7 5 8 5 3 4 6 1 1 5 5 0 7 2 3 6 4 1 2 4 1 5
## [9351] 4 2 0 4 8 6 1 9 0 2 5 6 9 3 6 3 6 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
## [9385] 7 8 9 0 1 2 3 5 6 7 8 1 0 9 5 7 5 1 8 6 9 0 4 1 9 3 8 4 4 7 0 1 9 2
## [9419] 8 7 8 2 3 9 6 0 6 5 5 3 3 3 9 8 1 1 0 6 1 0 0 6 2 1 1 3 2 7 7 8 8 7
## [9453] 8 4 6 0 2 0 7 0 3 6 8 7 1 5 9 9 3 7 2 4 9 4 3 6 2 2 5 3 2 5 5 9 4 1
## [9487] 7 2 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 1 0
## [9521] 1 2 7 5 3 4 4 0 0 6 9 6 6 5 7 2 3 4 4 9 1 4 0 7 9 5 7 2 3 1 4 4 0 9
## [9555] 9 6 1 8 3 3 7 3 9 8 8 4 7 7 6 2 1 9 8 7 8 8 7 2 2 3 9 3 3 5 5 0 7 4
## [9589] 5 6 5 1 4 1 1 2 8 2 6 1 5 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
## [9623] 1 2 3 4 5 6 7 8 8 0 6 0 1 2 3 7 9 4 7 1 9 1 7 1 4 0 0 1 7 5 7 1 3 3
## [9657] 3 1 6 9 7 1 3 0 7 6 0 8 9 4 3 5 4 8 1 5 9 0 6 3 3 8 1 4 7 5 2 0 0 1
## [9691] 7 8 9 6 8 8 2 3 6 1 2 9 5 2 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
## [9725] 0 1 2 3 4 6 6 7 8 9 7 4 6 1 4 0 9 9 3 7 8 0 7 5 8 5 3 2 2 0 5 5 6 0
## [9759] 3 8 1 0 3 0 4 7 4 9 2 9 0 7 1 7 1 6 6 0 6 2 8 7 6 4 9 9 5 3 7 4 3 0
## [9793] 4 6 6 1 1 3 2 1 0 0 1 2 3 4 7 8 9 0 1 2 3 4 5 6 7 8 0 1 2 3 4 7 8 9
## [9827] 0 8 3 9 5 5 2 6 8 4 1 7 1 2 3 5 6 9 1 1 1 2 1 2 0 7 7 5 8 2 9 8 6 7
## [9861] 3 4 6 8 7 0 4 2 7 7 5 4 3 4 2 8 1 5 1 0 2 3 3 5 7 0 6 8 6 3 9 9 5 2
## [9895] 7 7 1 0 1 7 8 9 0 1 0 3 4 5 6 7 8 0 1 2 3 4 7 8 9 7 8 6 4 1 9 3 8 4
## [9929] 4 7 0 1 9 2 8 7 8 2 6 0 6 5 3 3 3 9 1 4 0 6 1 0 0 6 2 1 1 7 7 8 4 6
## [9963] 0 7 0 3 6 8 7 1 5 2 4 9 4 3 6 4 1 7 2 6 6 0 1 2 3 4 5 6 7 8 9 0 1 2
## [9997] 3 4 5 6
```

Example 2

Import the Fashion MNIST dataset

```
fashion_mnist <- dataset_fashion_mnist()

c(train_images, train_labels) %<-% fashion_mnist$train
c(test_images, test_labels) %<-% fashion_mnist$test

class_names = c('T-shirt/top',
                'Trouser',
                'Pullover',
                'Dress',
                'Coat',
                'Sandal',
                'Shirt',
                'Sneaker',
```

```r
                'Bag',
                'Ankle boot')
```

Explore the data

```r
dim(train_images)
```

```
## [1] 60000    28    28
```

```r
dim(train_labels)
```

```
## [1] 60000
```

```r
train_labels[1:20]
```

```
##  [1] 9 0 0 3 0 2 7 2 5 5 0 9 5 5 7 9 1 0 6 4
```

```r
dim(test_images)
```

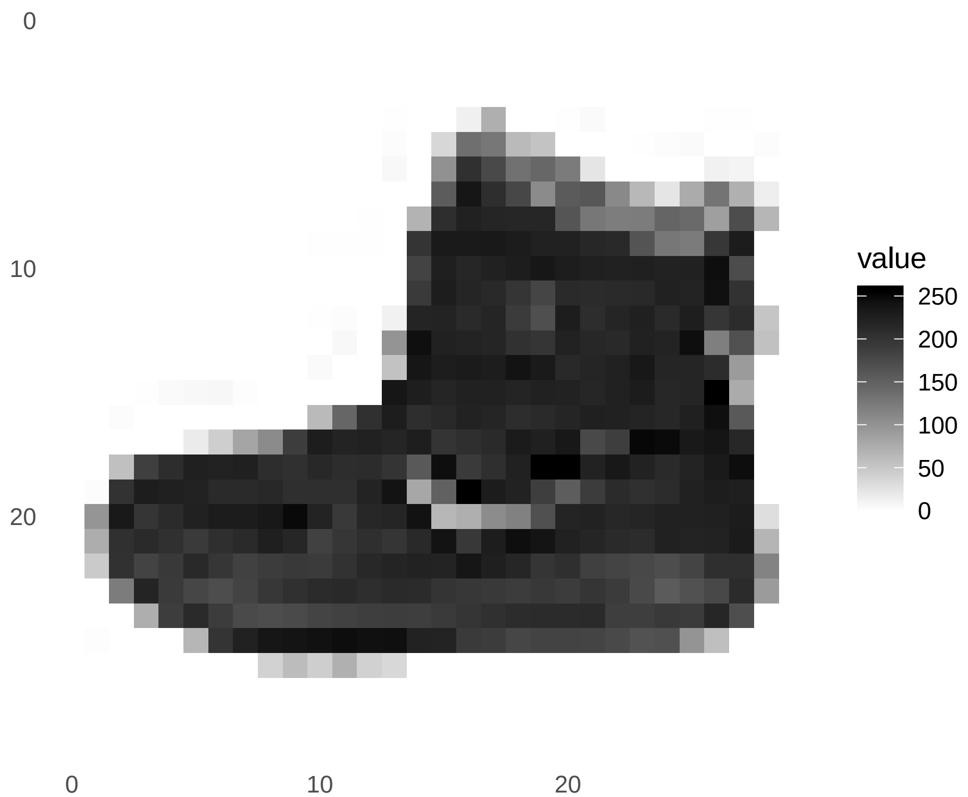
```
## [1] 10000    28    28
```

```r
dim(test_labels)
```

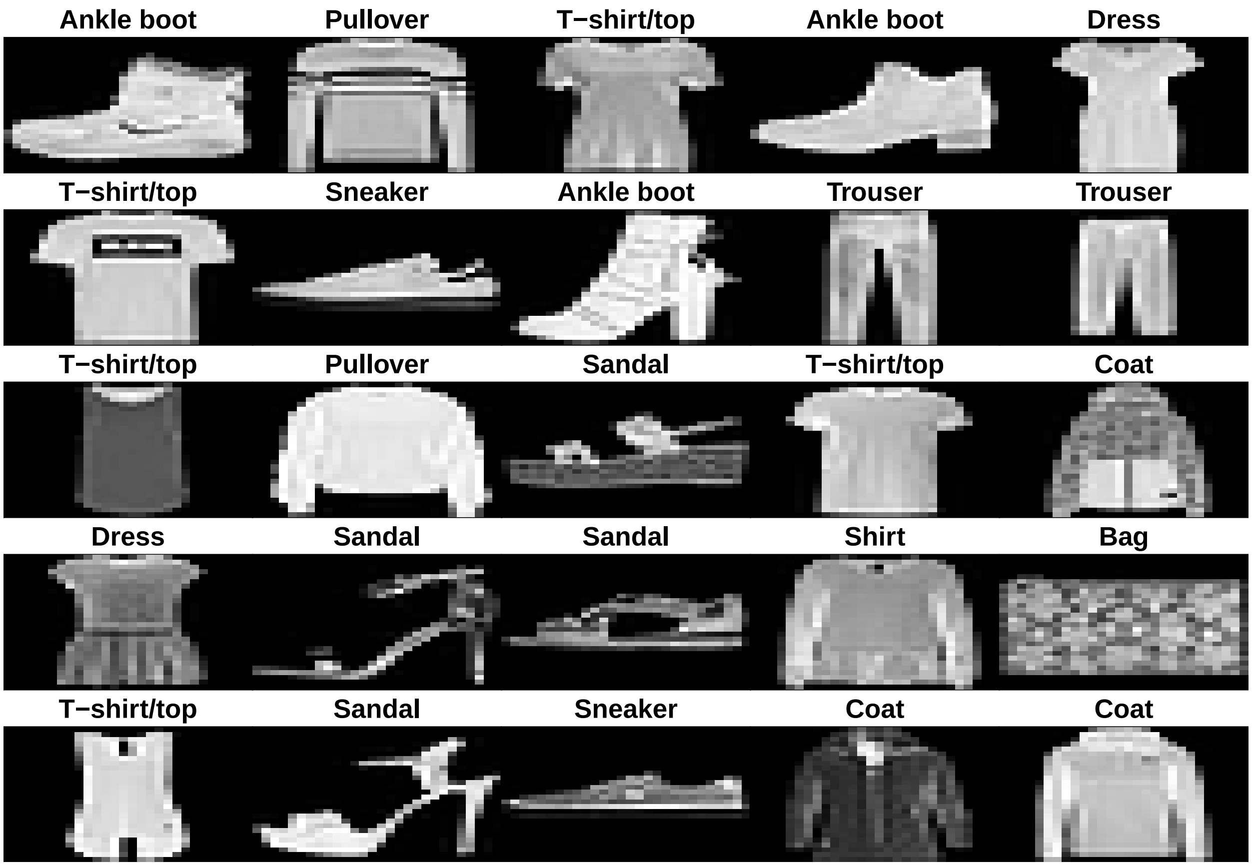
```
## [1] 10000
```

Preprocess the data

```r
library(tidyr)
library(ggplot2)

image_1 <- as.data.frame(train_images[1, , ])
colnames(image_1) <- seq_len(ncol(image_1))
image_1$y <- seq_len(nrow(image_1))
image_1 <- gather(image_1, "x", "value", -y)
image_1$x <- as.integer(image_1$x)

ggplot(image_1, aes(x = x, y = y, fill = value)) +
  geom_tile() +
  scale_fill_gradient(low = "white", high = "black", na.value = NA) +
  scale_y_reverse() +
  theme_minimal() +
  theme(panel.grid = element_blank())   +
  theme(aspect.ratio = 1) +
  xlab("") +
  ylab("")
```




```
train_images <- train_images / 255
test_images <- test_images / 255

par(mfcol=c(5,5))
par(mar=c(0, 0, 1.5, 0), xaxs='i', yaxs='i')
for (i in 1:25) {
  img <- train_images[i, , ]
  img <- t(apply(img, 2, rev))
  image(1:28, 1:28, img, col = gray((0:255)/255), xaxt = 'n', yaxt = 'n',
        main = paste(class_names[train_labels[i] + 1]))
}
```



Build the model

```
model <- keras_model_sequential()
model %>%
  layer_flatten(input_shape = c(28, 28)) %>%
  layer_dense(units = 128, activation = 'relu') %>%
  layer_dense(units = 10, activation = 'softmax')

model %>% compile(
  optimizer = 'adam',
  loss = 'sparse_categorical_crossentropy',
  metrics = c('accuracy')
)

model %>% fit(train_images, train_labels, epochs = 5)

score <- model %>% evaluate(test_images, test_labels)

cat('Test loss:', score$loss, "\n")
```

```
## Test loss: 0.3479988
```

```
cat('Test accuracy:', score$acc, "\n")
```

```
## Test accuracy: 0.8768
```

```r
predictions <- model %>% predict(test_images)

predictions[1, ]
```

```
##  [1] 8.431207e-06 1.438180e-08 1.167668e-08 5.673658e-08 7.317357e-07
##  [6] 1.520386e-02 6.743840e-06 8.637270e-02 6.766369e-04 8.977308e-01
```

```r
which.max(predictions[1, ])
```

```
## [1] 10
```

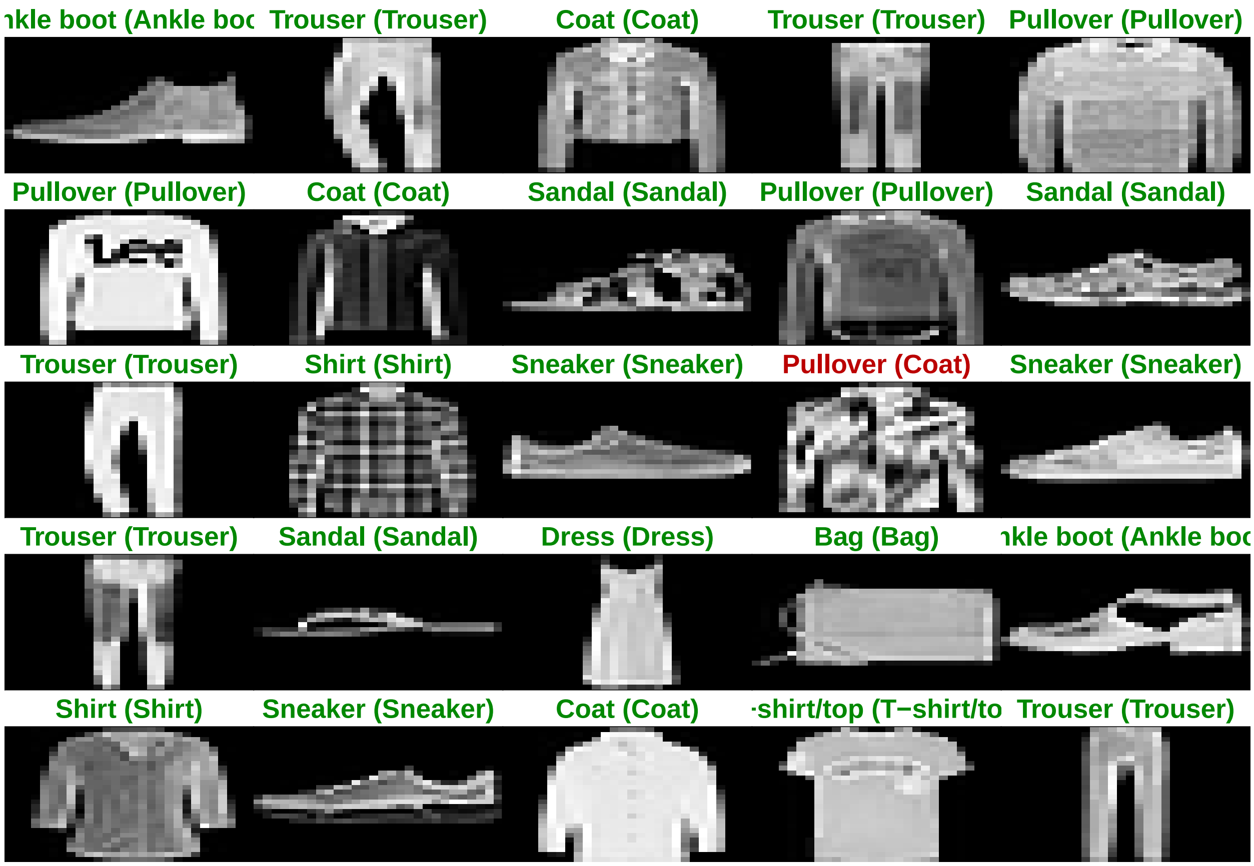
```r
class_pred <- model %>% predict_classes(test_images)
class_pred[1:20]
```

```
##  [1] 9 2 1 1 6 1 4 6 5 7 4 5 7 3 4 1 2 2 8 0
```

```r
test_labels[1]
```

```
## [1] 9
```

```r
par(mfcol=c(5,5))
par(mar=c(0, 0, 1.5, 0), xaxs='i', yaxs='i')
for (i in 1:25) {
  img <- test_images[i, , ]
  img <- t(apply(img, 2, rev))
  # subtract 1 as labels go from 0 to 9
  predicted_label <- which.max(predictions[i, ]) - 1
  true_label <- test_labels[i]
  if (predicted_label == true_label) {
    color <- '#008800'
  } else {
    color <- '#bb0000'
  }
  image(1:28, 1:28, img, col = gray((0:255)/255), xaxt = 'n', yaxt = 'n',
        main = paste0(class_names[predicted_label + 1], " (",
                      class_names[true_label + 1], ")"),
        col.main = color)
}
```




```
# Grab an image from the test dataset
# take care to keep the batch dimension, as this is expected by the model
img <- test_images[1, , , drop = FALSE]
dim(img)
```

```
## [1]  1 28 28
```

```
predictions <- model %>% predict(img)
predictions
```

```
##               [,1]        [,2]         [,3]         [,4]         [,5]
## [1,] 8.431225e-06 1.43818e-08 1.167663e-08 5.673649e-08 7.317352e-07
##             [,6]         [,7]       [,8]        [,9]     [,10]
## [1,] 0.01520382 6.743841e-06 0.08637261 0.000676637 0.8977309
```

```
# subtract 1 as labels are 0-based
prediction <- predictions[1, ] - 1
which.max(prediction)
```

```
## [1] 10
```

```
class_pred <- model %>% predict_classes(img)
class_pred
```

```
## [1] 9
```