Fashion MNIST Deep Learning Project

TAO JIN

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In this project, we will use two Deep learning models to Classify the image from Fashion-MNIST dataset

- Basic Model (fully connected layer model)
- Convolutional neural networks (ConvNets)

All model will use the Keras framework with R implementation

Fashion-MNIST Dataset

- *https://www.kaggle.com/zalando-research/fashionmnist/data*
- 60000 images for training and 10000 images for testing
- Each example is a 28x28 gray-scale image, associated with a label from 10 classes

  0 T-shirt/top,1 Trouser, 2 Pullover, 3 Dress, 4 Coat, 5 Sandal,6 Shirt, 7 Sneaker, 8 Bag ,9 Ankle boot

- The dataset is CSV format. The detailed format is **label, pixel1, pixel2, pixel3, ... pixel784**. Each image is 28 pixels in height and 28 pixels in width, for a total of 784 pixels in total

Define the Problem and Assembling Data Set

Problem: Train the 60000 images and test 10000 images to classify the image's label

- Problem Type: Multi-Class and single-label classification
- Model Configuration: the ***softmax*** as the last-layer's activation and the loss function will use the ***categorical_crossentropy***.
- Hyper-parameters setting : use the ***dropout*** and ***L2 regularization*** to reduce over-fitting effects.

Assembling Data Set

- Using the dataset_fashion_mnist() function from Keras to download the dataset (simple model)
- Downloaded from the Kaggle.com, then use the read_csv() to manipulate the data (ConvNets Model)

Simple Neural Network Model

Data Preparation

- dataset_fashion_mnist() function from Keras to get the data.
- prepare the data for training we convert the 3-d arrays into matrices by reshaping width and height into a single dimension (28x28 images are flattened into length 784 vectors).
- Convert the gray-scaled normalization

```
FashionMNIST <- dataset_fashion_mnist()
Train_X <- FashionMNIST$train$x
Train_Y <- FashionMNIST$train$y
Test_X <- FashionMNIST$test$x
Test_Y <- FashionMNIST$test$y
# Reshape
Train_X <- array_reshape(Train_X, c(nrow(Train_X), 784))
Test_X <- array_reshape(Test_X, c(nrow(Test_X), 784))
# Value Normalization
Train_X <- Train_X / 255
Test_X <- Test_X / 255
```

Model

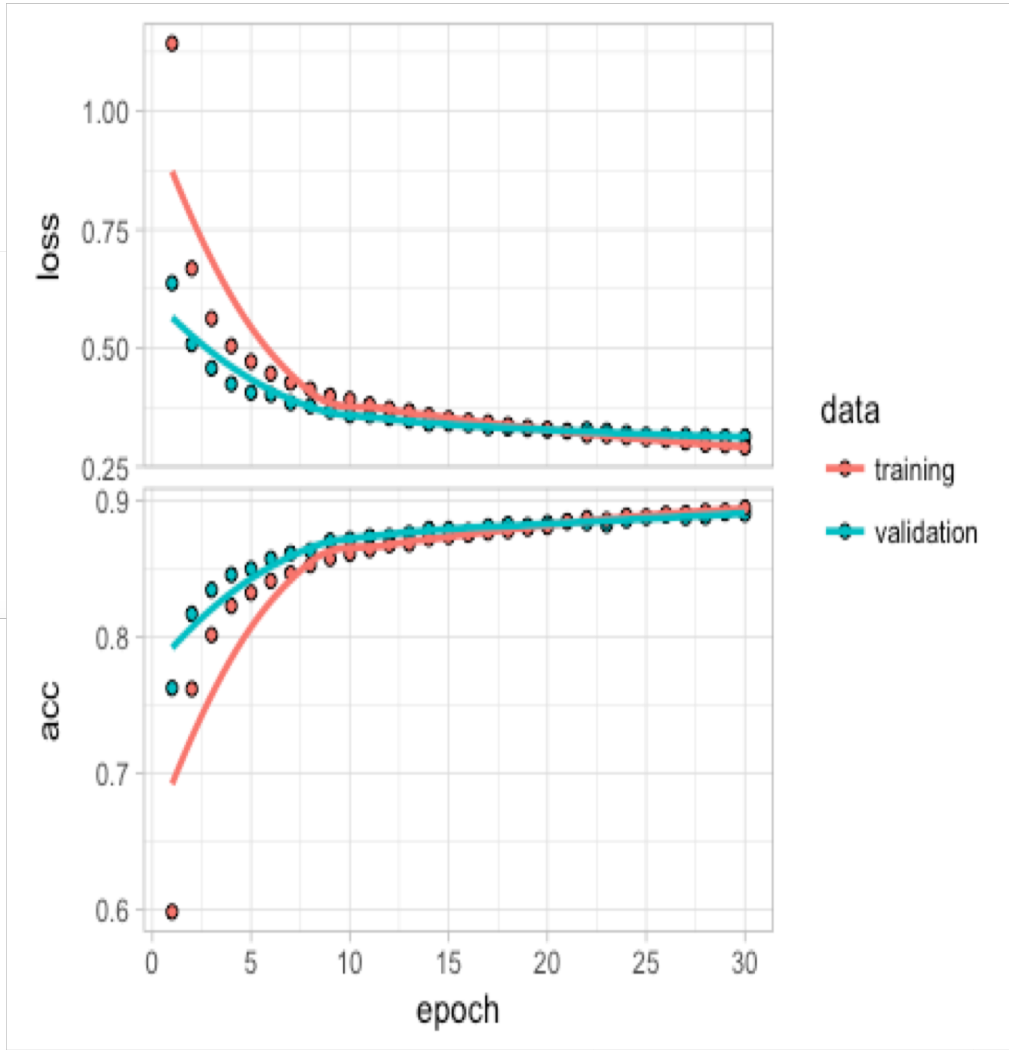
- use a simple stack of fully connected (“dense”) layers with “relu” activations.
- introduce the dropout method to avoid the over-fitting.

```
model <- keras_model_sequential()
model %>%
  layer_dense(units = 256, activation = 'relu', input_shape = c(784)) %>%
  layer_dropout(rate = 0.4) %>%
  layer_dense(units = 256, activation = 'relu') %>%
  layer_dropout(rate = 0.3) %>%
  layer_dense(units = 256, activation = 'relu') %>%
  layer_dropout(rate = 0.2) %>%
  layer_dense(units = 10, activation = 'softmax')
```

Simple Neural Network Model

- **Simple deep learning model achieves an accuracy of 88.11% and loss of 34.15%.**

```
> summary(model)
_____________________________________________________________________________
Layer (type)                 Output Shape              Param #
=============================================================================
dense_1 (Dense)              (None, 256)               200960
_____________________________________________________________________________
dropout_1 (Dropout)          (None, 256)               0
_____________________________________________________________________________
dense_2 (Dense)              (None, 256)               65792
_____________________________________________________________________________
dropout_2 (Dropout)          (None, 256)               0
_____________________________________________________________________________
dense_3 (Dense)              (None, 256)               65792
_____________________________________________________________________________
dropout_3 (Dropout)          (None, 256)               0
_____________________________________________________________________________
dense_4 (Dense)              (None, 10)                2570
=============================================================================
Total params: 335,114
Trainable params: 335,114
Non-trainable params: 0
_____________________________________________________________________________
>
```



Convolutional Neural Networks Model

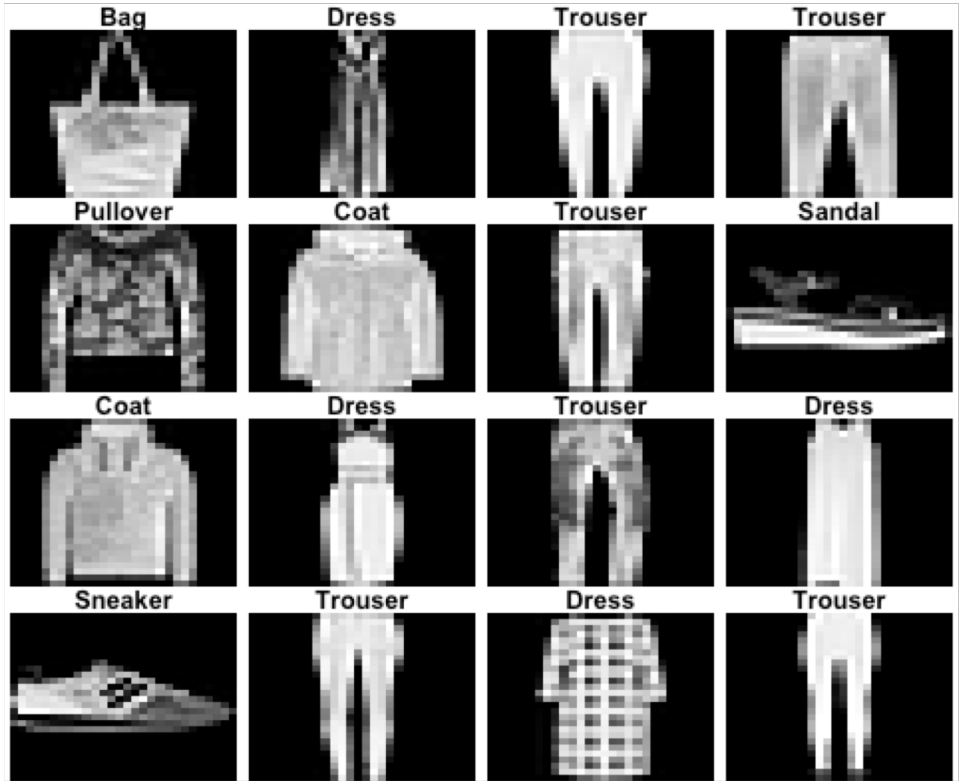
Data Preparation

- **In the ConvNets model, we will use the original CSV data and prepare the 4D Tensors image data format.**

```
# Data downloaded from https://www.kaggle.com/zalando-research/fashionmnist
TrainSetData <- read_csv("fashion-mnist_train.csv", col_types = cols(.default = "i"))
TestSetData <- read_csv("fashion-mnist_test.csv", col_types = cols(.default = "i"))
```

- **Unflattening, Reshaping and Normalization the data**
- **Plot the images as examples**

```
# Function to plot image from a matrix x
plot_image <- function(x, title = "", title.color = "black") {
  dim(x) <- c(ImgRows, ImgCols)
  image(rotate(rotate(x)), axes = FALSE,
        col = grey(seq(0, 1, length = 256)),
        main = list(title, col = title.color))
}
```



Convolutional Neural Networks Model

ConvNets Model

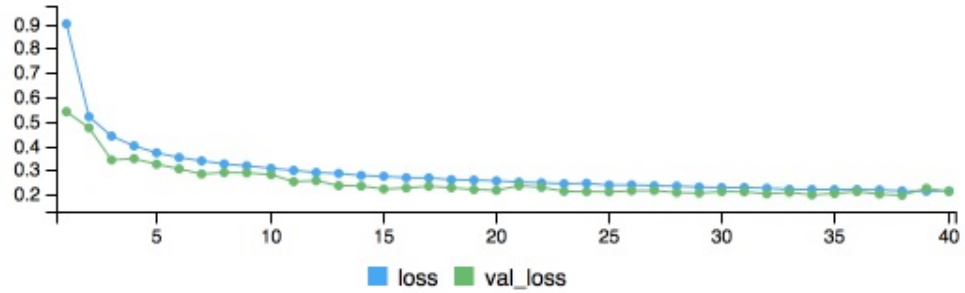
- the stack of ***layer_conv_2d*** and ***layer_max_pooling_2d*** layers.
- A convent takes as input tensors of (***image_height, image_width, image_channel***). In this case, the input for the first layer's size is ***input_shape*** = (28,28,1)
- Batch size is 256, epochs is 40, kernel size first is (5,5) then (3,3), dropout rate is 0.25/0.25/0.4/0.3

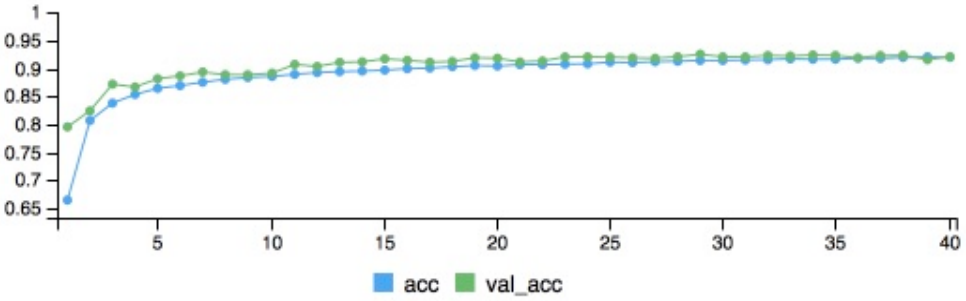
```
model <- keras_model_sequential()
model %>%
  layer_conv_2d(filters = 32, kernel_size = c(5,5), activation = 'relu',
                input_shape = input_shape) %>%
  layer_max_pooling_2d(pool_size = c(2, 2)) %>%
  layer_dropout(rate = 0.25) %>%
  layer_conv_2d(filters = 64, kernel_size = c(3,3), activation = 'relu') %>%
  layer_max_pooling_2d(pool_size = c(2, 2)) %>%
  layer_dropout(rate = 0.25) %>%
  layer_conv_2d(filters = 128, kernel_size = c(3,3), activation = 'relu') %>%
  layer_dropout(rate = 0.4) %>%
  layer_flatten() %>%
  layer_dense(units = 128, activation = 'relu') %>%
  layer_dropout(rate = 0.3) %>%
  layer_dense(units = num_classes, activation = 'softmax')
```

Convolutional Neural Networks Model

- **ConvNets model achieves an accuracy of 91.85% and loss is 20%, up from the previous model's accuracy of 88.11% and loss of 34.15%.**

```
> summary(model)
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 24, 24, 32)        832
_________________________________________________________________
max_pooling2d_1 (MaxPooling2D) (None, 12, 12, 32)      0
_________________________________________________________________
dropout_1 (Dropout)          (None, 12, 12, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 10, 10, 64)        18496
_________________________________________________________________
max_pooling2d_2 (MaxPooling2D) (None, 5, 5, 64)        0
_________________________________________________________________
dropout_2 (Dropout)          (None, 5, 5, 64)          0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 3, 3, 128)         73856
_________________________________________________________________
dropout_3 (Dropout)          (None, 3, 3, 128)         0
_________________________________________________________________
flatten_1 (Flatten)          (None, 1152)              0
_________________________________________________________________
dense_1 (Dense)              (None, 128)               147584
_________________________________________________________________
dropout_4 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_2 (Dense)              (None, 10)                1290
=================================================================
Total params: 242,058
Trainable params: 242,058
Non-trainable params: 0
_________________________________________________________________
>
```

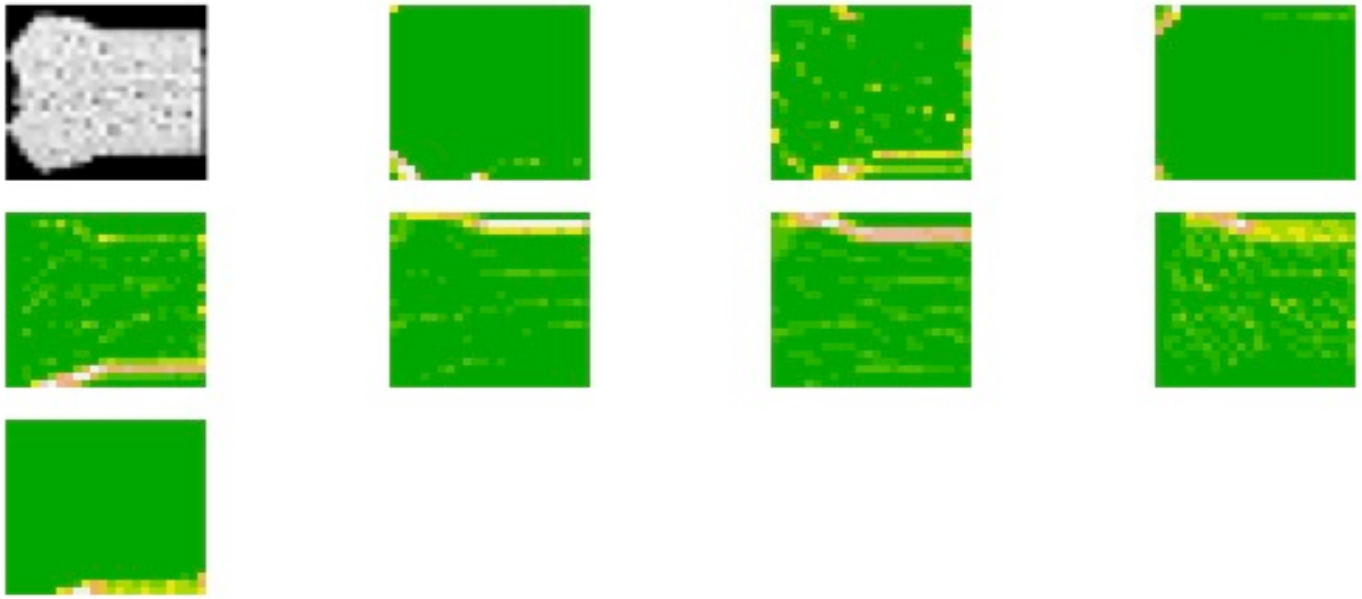




Convolutional Neural Networks Model

Visualizing the Model Predictions

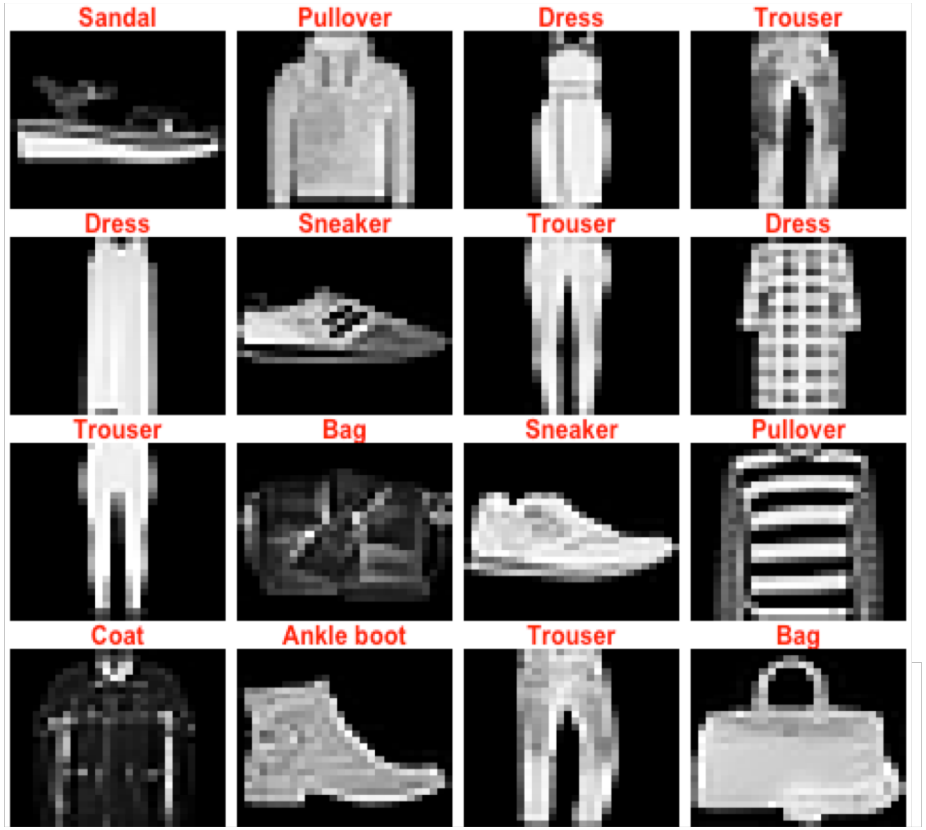
- Lower layer acts as a collection of various edge detectors
- Higher layer carry increasingly less information about the visual contents of the image, and increasingly more information related to the class of the image



Convolutional Neural Networks Model

- **Visualizing the Model Predictions**

```
for (i in 1:32) {
  n_row <- i * 10
  T_Tensor <- Train_X[n_row, , , 1]
  dim(T_Tensor) <- c(1, ImgRows, ImgCols, 1)
  pred <- model %>% predict(T_Tensor)
  plot_image(Train_X[n_row, , , 1],
             Fashion_Labels[which.max(pred)],
             "red")
}
```



Convolutional Neural Networks Model

Summary

- Our ConvNets model achieved an accuracy of 91.85%. It turns out our classifier does better than the Kaggle's best baseline reported here, which is an SVM classifier with mean accuracy of 89.7%.
- Comparing the simple model, ConvNets is the best model for the attacking the image classification problems.
- Tuning the model and hyper-parameters is very important to improve the accuracy.