Deep Learning with Keras, Tensorflow and Statistical Programming Language, R

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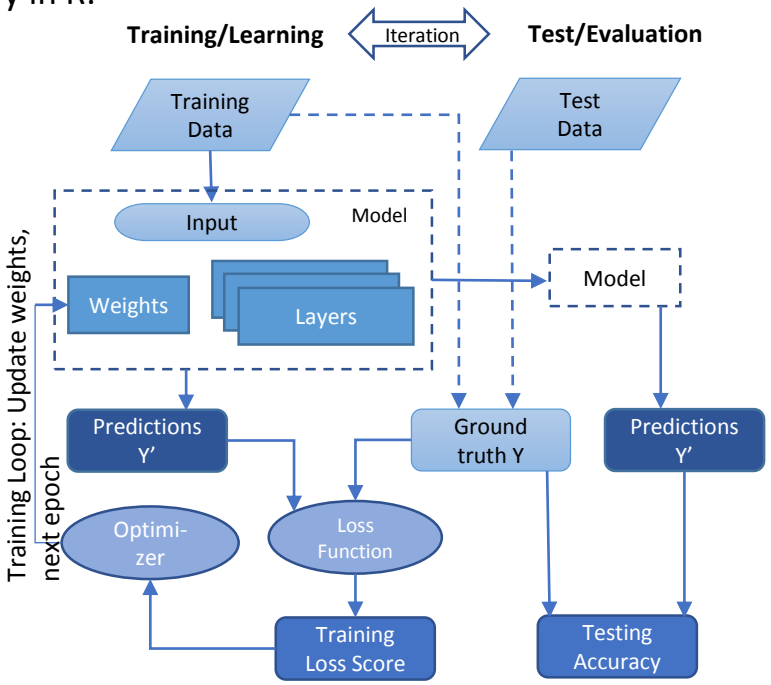
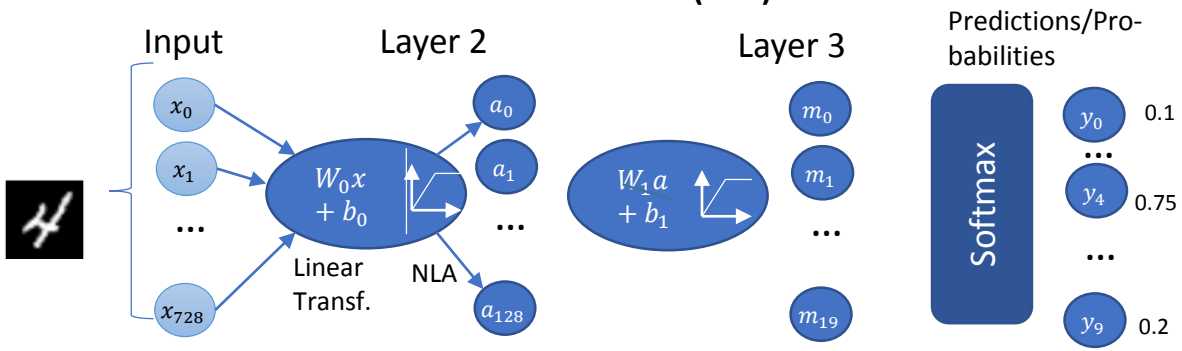
1. **Case Study**: The **MNIST database** comprises 60,000 training examples and 10,000 test examples of the handwritten digits 0–9, formatted as 28x28-pixel matrices, with each pixel carrying a grayscale value 0-255:

2. **Building a handwritten digit classifier in R**: Open-source numerical libraries such as Keras and Tensorflow are now available in the R programming language environment. We show a well-known **image recognition application** for the MNIST database using the Keras library in R.

3. **The Statistical Machine Learning workflow:**
   a) **Data representation and pre-processing**: Preprocess data into chosen representation and divide data into training and test datasets
   b) Define a **network architecture**, number of layers and elements in each layer, using **Keras/TF** modules
   c) Adjust network configurations, such as functions and learning rates. Train the model on training set
   d) **Evaluate model** on the test set and iterate back to c until satisfied



4. **The heart of the Network are the layers, comprised of linear transformation and non-linear activation (NLA) function**:



5. **Keras/Tensorflow libraries** allow one to easily implement, compute and port a given network architecture:

```
library(keras)
network <- keras_model_sequential() %>%
  layer_dense(units = 128, activation = "relu",
              input_shape = c(28*28)) %>%
  layer_dense(units = 20, activation = 'relu') %>%
  layer_dense(units = 10, activation = "softmax")

network %>% compile(
  optimizer = "rmsprop",
  loss = "categorical_crossentropy",
  metrics = c("accuracy")
```

6. The charts to the right show the progress of the **training loop**. In each **epoch** (horizontal axis), the learning algorithm traverses the training dataset and updates the weights

7. Ultimately, our model is able to achieve an accuracy of over 97% over 20 epochs in less than a minute.