# Keras

In this module we will introduce <u>Keras (https://keras.io/)</u>, a high level API for Neural Networks.

To be specific

- we will mostly restrict ourselves to the Keras Sequential model
- this will greatly simplify your learning and coding
- it will restrict the type of Deep Learning programs that you can write
  - but not a meaningful restriction for the simple programs that you will write in this course

## After we introduce the high level Keras API

- we will review the history of Deep Learning programming to see how we got here
- this will give you greater insight into what Keras does "under the covers"
  - appreciate history
  - aid your diagnostics

### Note:

The code snippets in this notebook are *fragments* of a larger <u>notebook</u> (<u>DNN TensorFlow example.ipynb</u>)

• are illustrative: will not actually execute in this notebook but will in the complete notebook

# Confusion warning:

- There are two similar but different packages that implement Keras
  - one built into TensorFlow (the one we will use)
  - a separate project

### TL;DR

### YES

- import tensorflow as tf tf.keras.layers.Dense(...)
- from tensorflow import keras keras.layers.Dense(...)

### NO

import keras keras.layers.Dense( ... )

If you want to know the details, visit this <u>notebook</u> (<u>Tensorflow Keras Archaeology.ipynb#tensorflow.keras-vs-keras-(Confusion-alert)</u>)

# The Keras Sequential Model

**Reference**: Getting started with the Keras Sequential Model (https://keras.io/getting-started/sequential-model-guide/)

Keras has two programming models

- Sequential
- Functional

We will start with the Sequential model

The Sequential model allows you to build Neural Networks (NN) that are composed of a sequence of layers

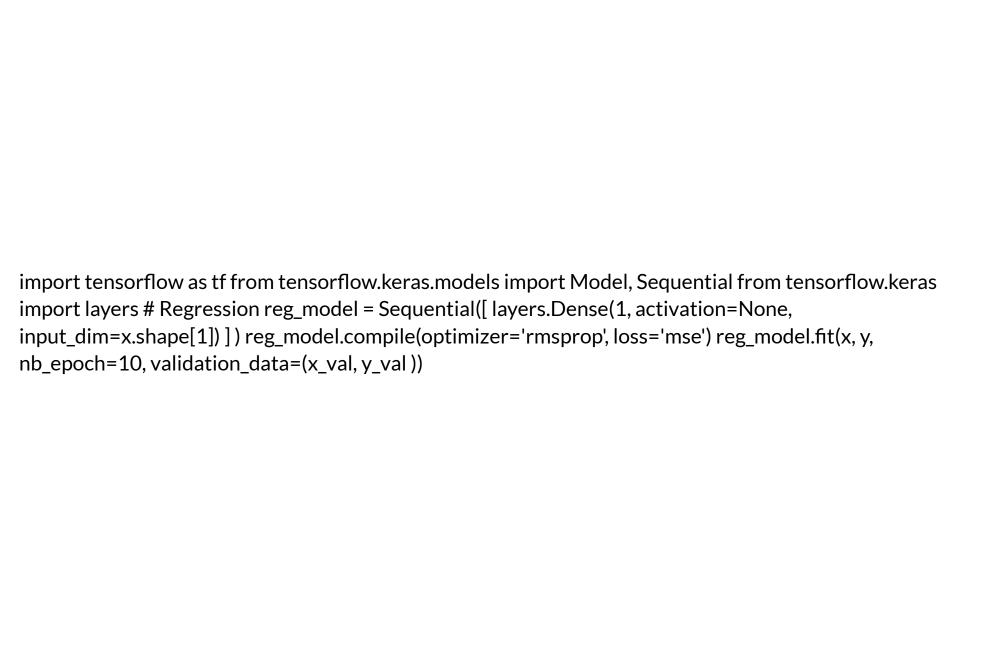
- just like our cartoon
- a very prevalent paradigm

This will likely be sufficient in your initial studies

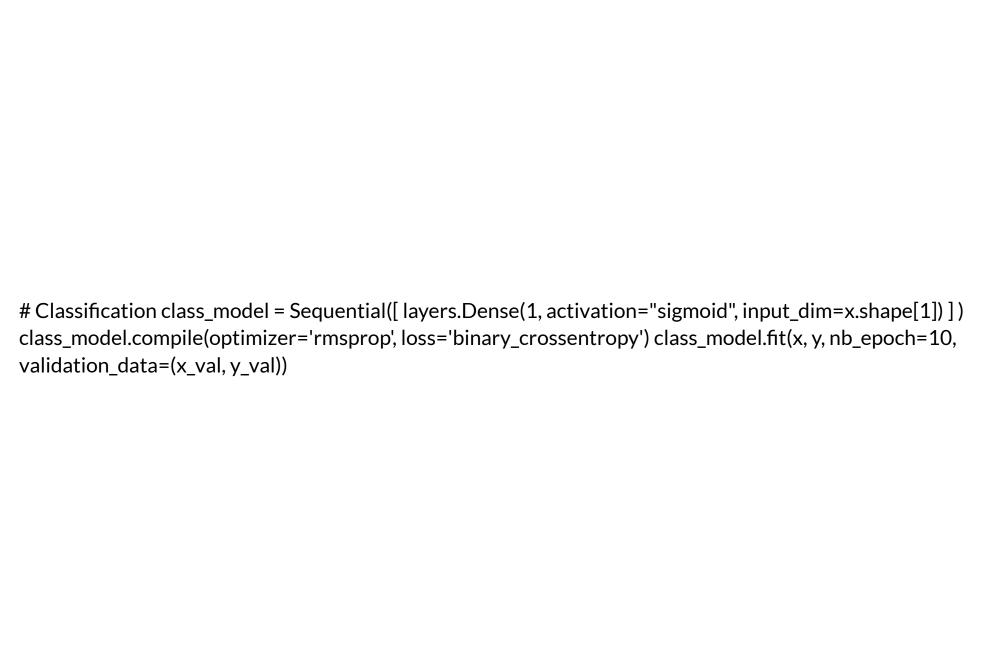
- but it restricts the architecture of the Neural Networks that you can build
- use the Functional API for full generality
  - but it might appear more complicated

Let's jump into some code.

Some old friends, in new clothing:



- A model uses the Sequential architecture
- A sequence (implemented as an array) of layers
  - Single element array
  - Consisting of a Dense (Fully connected) layer
    - $\circ$  with 1 output
    - No activation
    - Implements Regression
- Loss is mse



- A model uses the Sequential architecture
- A sequence (implemented as an array) of layers
  - Single element array
  - Consisting of a Dense (Fully connected) layer
    - with 1 output: binary classification
    - sigmoid activation
    - Implements Classification
- Lossis binary\_crossentropy

## TL;DR

- Both examples are a single layer
  - Dense, with 1 unit ("neuron")
- Regression example
  - No activation
  - MSE loss
- Binary classification example
  - Sigmoid activation
  - Binary cross entropy loss

Hopefully you get the idea.

Let's explore a slightly more complicated model.



- A model uses the Sequential architecture
- A sequence (implemented as an array) of layers
  - 3 layers (3 element array)
  - 2 Dense layers
    - with varying number of outputs: n\_hidden\_1,n\_hidden\_2
    - reluactivation
  - A Dense layer implementing Multinomial Classification
    - o number of outputs equal to number of classes
    - softmax activation

- The first two layers "transform" the input
- The "head" layer implements Multinomial Classification

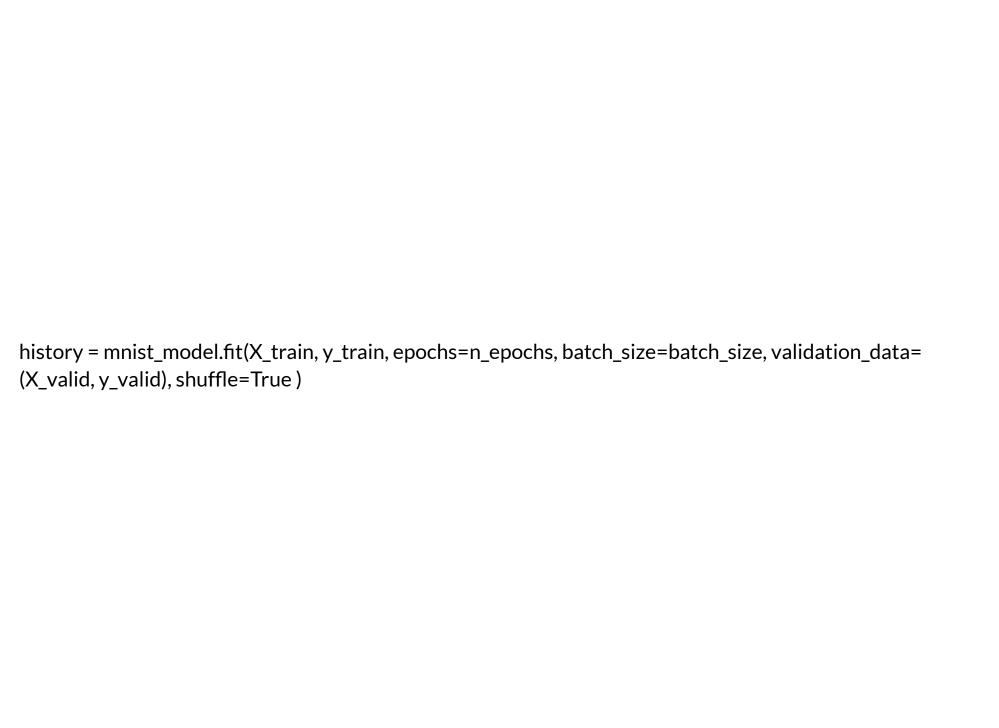
To use the model, you first need to "compile" it

metrics = [ "acc" ] mnist\_model.compile(optimizer='adam', loss='sparse\_categorical\_crossentropy', metrics=metrics)

"Compiling" is quite significant as we will demonstrate later

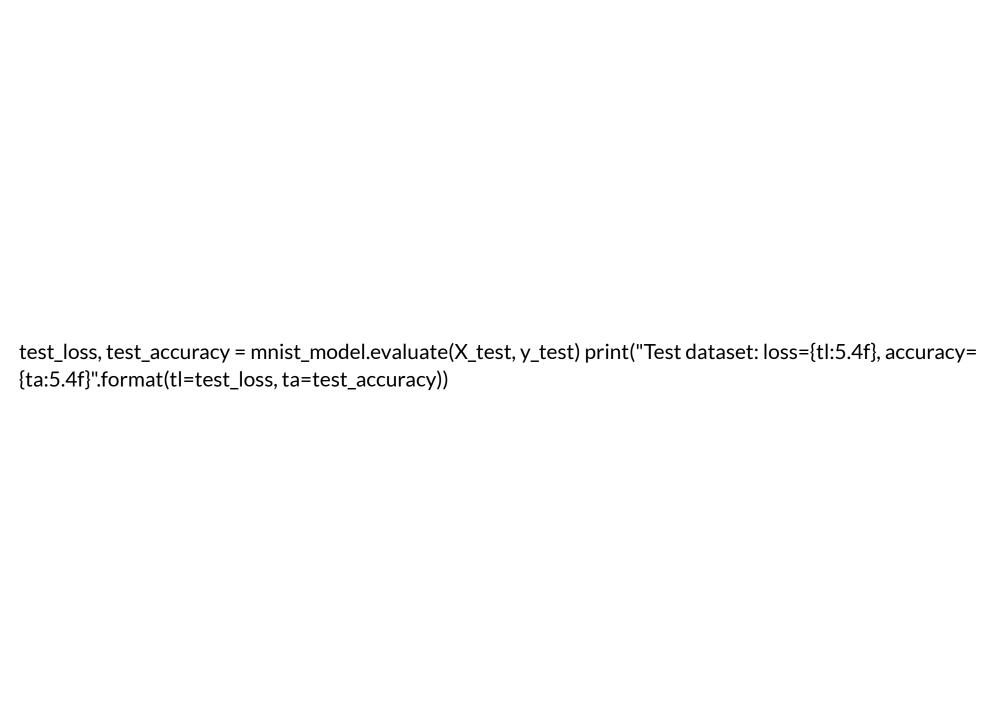
• For now: it is where you define the Loss function

Next, just as in sklearn: you "fit" the model to the training data.



Once the model is fit, you can predict, just like sklearn.

Here we evaluate the model on the Test dataset.



# The idea is quite simple

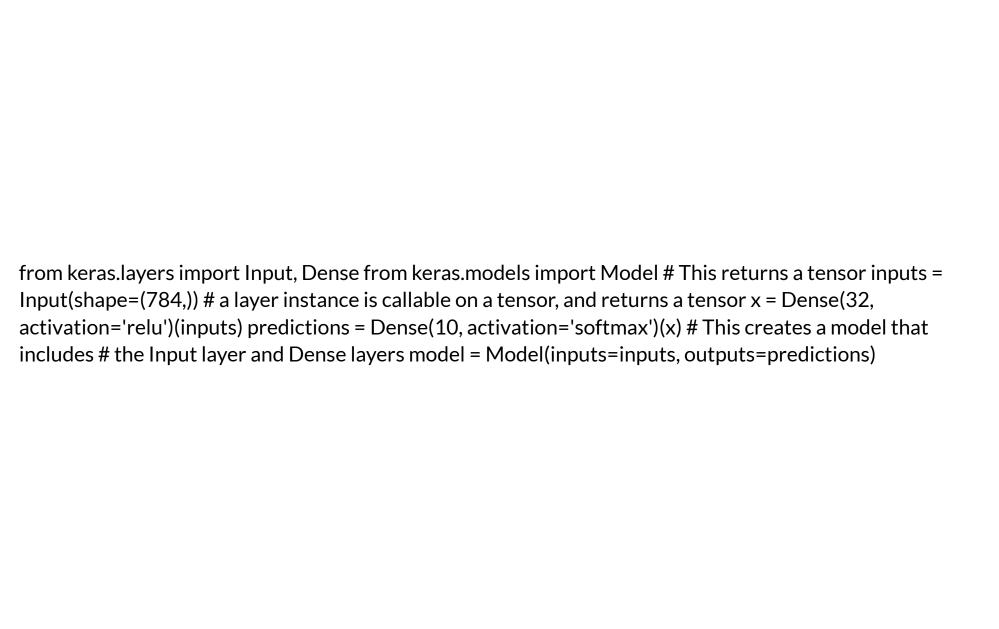
- Keras Sequential implements an sklearn-like API
  - define a model
  - fit the model
  - predict

We have glossed over a lot of details

- What does each layer do?
- Why do we need to "compile"?
  - and why does it need an optimizer?

# The Keras Functional Model

- More verbose than Sequential
- Also more flexible
  - you can define more complex computation graphs (multiple inputs/outputs, shared layers)



### Highlights:

- Manually invoke a single layer at a time
  - Passing as input the output of the prior layer.
- You must define an Input layer (placeholder for the input/define its shape)
  - Sequential uses the input\_shape= parameter to the first layer
- You "wrap" the graph into a "model" by a Model statement
  - looks like a function definition
    - names the input and output formal parameters
  - a Model acts just like a layer (but with internals that you create)



As a beginner, you will probably exclusively use the Sequential model. Keep the Functional API in the back of your mind.

# Let's code!

Lets see a working notebook.

Two options

- Run on your local machine: <u>DNN Tensorflow example Notebook local</u> (<u>DNN TensorFlow example.ipynb</u>) (local)
  - Tensorflow version 2+ only!
- Run on Google Colab: <u>DNN Tensorflow example Notebook from github</u>
  (<a href="https://colab.research.google.com/github/kenperry-public/ML Fall 2021/blob/master/DNN TensorFlow example.ipynb">https://colab.research.google.com/github/kenperry-public/ML Fall 2021/blob/master/DNN TensorFlow example.ipynb</a>) (Colab)

```
In [1]: print("Done")
```

Done