Even though the libraries for [R from Python](https://rpy2.bitbucket.io/), or [Python from R](https://rstudio.github.io/reticulate/) code execution existed since years and despite of a recent [announcement](http://wesmckinney.com/blog/announcing-ursalabs/) of [Ursa Labs](https://ursalabs.org/) foundation by [Wes McKinney](http://wesmckinney.com/) who is aiming to join forces with RStudio foundation, [Hadley Wickham](http://hadley.nz/) in particularly, (find more [here](https://qz.com/1270139/r-and-python-are-joining-forces-in-the-most-ambitious-crossover-event-of-the-year-for-programmers/)) to improve data scientists workflow and unify libraries to be used not only in Python, but in any programming language used by data scientists, some data professionals are still very strict on the language to be used for ANN models limiting their dev. environment exclusively to Python.

As a continuation of my [R vs. Python comparison](https://www.dkisler.de/2018/02/19/r-versus-python-loops-required-time/), I decided to test performance of both languages in terms of time required to train a [convolutional neural network](https://cs231n.github.io/convolutional-networks/) based model for image recognition. As the starting point, I took [the blog post](https://shirinsplayground.netlify.com/2018/06/keras_fruits/) by [Dr. Shirin Glander](https://www.linkedin.com/in/shirin-glander-01120881/) on how easy it is to build a CNN model in R using Keras.

A few words about [Keras](https://keras.io/). It is a Python library for artificial neural network ML models which provides high level fronted to various deep learning frameworks with [Tensorflow](https://www.tensorflow.org/) being the default one.  
Keras has many pros with the following among the others:

* Easy to build complex models just in few lines of code => perfect for dev. cycle to quickly experiment and check your ideas
* Code recycling: one can easily swap the backend framework (let’s say from [CNTK](https://docs.microsoft.com/en-ca/cognitive-toolkit/) to [Tensorflow](https://www.tensorflow.org/) or vice versa) => [DRY principle](https://en.wikipedia.org/wiki/Don%27t_repeat_yourself)
* Seamless use of GPU => perfect for fast model tuning and experimenting

Since Keras is written in Python, it may be a natural choice for your dev. environment to use Python. And that was the case until about a year ago when [RStudio](https://www.rstudio.com/) founder [J.J.Allaire](https://en.wikipedia.org/wiki/Joseph_J._Allaire) [announced](https://blog.rstudio.com/2017/09/05/keras-for-r/) release of [the Keras library for R](https://keras.rstudio.com/) in May’17. I consider this to be a turning point for data scientists; now we can be more flexible with dev. environment and be able to deliver result more efficiently with opportunity to extend existing solutions we may have written in R.

It brings me to the point of this post.  
**My hypothesis is**, when it comes to ANN ML model building with Keras, Python is not a must, and depending on your client’s request, or tech stack, R can be used without limitations and with similar efficiency.

**Image Classification with Keras**

In order to test my hypothesis, I am going to perform image classification using the [fruit images data](https://www.kaggle.com/moltean/fruits/data) from kaggle and train a CNN model with four hidden layers: two 2D convolutional layers, one pooling layer and one dense layer. [RMSProp](https://youtu.be/_e-LFe_igno) is being used as the [optimizer function](https://keras.io/optimizers/).

**Tech stack**

**Hardware**:  
CPU: Intel Core i7-7700HQ: 4 cores (8 threads), 2800 – 3800 (Boost) MHz core clock  
GPU: Nvidia Geforce GTX 1050 Ti Mobile: 4Gb vRAM, 1493 – 1620 (Boost) MHz core clock  
RAM: 16 Gb

**Software**:  
OS: Linux Ubuntu 16.04  
R: ver. 3.4.4  
Python: ver. 3.6.3  
Keras: ver. 2.2  
Tensorflow: ver. 1.7.0  
CUDA: ver. 9.0 (note that the current tensorflow version supports ver. 9.0 while the up-to-date version of cuda is 9.2)  
cuDNN: ver. 7.0.5 (note that the current tensorflow version supports ver. 7.0 while the up-to-date version of cuDNN is 7.1)

**Code**

The R and Python code snippets used for CNN model building are present bellow. Thanks to fruitful collaboration between F. Chollet and J.J. Allaire, the logic and functions names in R are alike the Python ones.

**R**

## Courtesy: Dr. Shirin Glander. Code source: https://shirinsplayground.netlify.com/2018/06/keras\_fruits/

library(keras)

start <- Sys.time()

fruit\_list <- c("Kiwi", "Banana", "Plum", "Apricot", "Avocado", "Cocos", "Clementine", "Mandarine", "Orange",

"Limes", "Lemon", "Peach", "Plum", "Raspberry", "Strawberry", "Pineapple", "Pomegranate")

# number of output classes (i.e. fruits)

output\_n <- length(fruit\_list)

# image size to scale down to (original images are 100 x 100 px)

img\_width <- 20

img\_height <- 20

target\_size <- c(img\_width, img\_height)

# RGB = 3 channels

channels <- 3

# path to image folders

path <- "path/to/folder/with/data"

train\_image\_files\_path <- file.path(path, "fruits-360", "Training")

valid\_image\_files\_path <- file.path(path, "fruits-360", "Test")

# optional data augmentation

train\_data\_gen %>% image\_data\_generator(

rescale = 1/255

)

# Validation data shouldn't be augmented! But it should also be scaled.

valid\_data\_gen <- image\_data\_generator(

rescale = 1/255

)

# training images

train\_image\_array\_gen <- flow\_images\_from\_directory(train\_image\_files\_path,

train\_data\_gen,

target\_size = target\_size,

class\_mode = 'categorical',

classes = fruit\_list,

seed = 42)

# validation images

valid\_image\_array\_gen <- flow\_images\_from\_directory(valid\_image\_files\_path,

valid\_data\_gen,

target\_size = target\_size,

class\_mode = 'categorical',

classes = fruit\_list,

seed = 42)

### model definition

# number of training samples

train\_samples <- train\_image\_array\_gen$n

# number of validation samples

valid\_samples <- valid\_image\_array\_gen$n

# define batch size and number of epochs

batch\_size <- 32

epochs <- 10

# initialise model

model <- keras\_model\_sequential()

# add layers

model %>%

layer\_conv\_2d(filter = 32, kernel\_size = c(3,3), padding = 'same', input\_shape = c(img\_width, img\_height, channels)) %>%

layer\_activation('relu') %>%

# Second hidden layer

layer\_conv\_2d(filter = 16, kernel\_size = c(3,3), padding = 'same') %>%

layer\_activation\_leaky\_relu(0.5) %>%

layer\_batch\_normalization() %>%

# Use max pooling

layer\_max\_pooling\_2d(pool\_size = c(2,2)) %>%

layer\_dropout(0.25) %>%

# Flatten max filtered output into feature vector

# and feed into dense layer

layer\_flatten() %>%

layer\_dense(100) %>%

layer\_activation('relu') %>%

layer\_dropout(0.5) %>%

# Outputs from dense layer are projected onto output layer

layer\_dense(output\_n) %>%

layer\_activation('softmax')

# compile

model %>% compile(

loss = 'categorical\_crossentropy',

optimizer = optimizer\_rmsprop(lr = 0.0001, decay = 1e-6),

metrics = 'accuracy'

)

# fit

hist <- fit\_generator(

# training data

train\_image\_array\_gen,

# epochs

steps\_per\_epoch = as.integer(train\_samples / batch\_size),

epochs = epochs,

# validation data

validation\_data = valid\_image\_array\_gen,

validation\_steps = as.integer(valid\_samples / batch\_size),

# print progress

verbose = 2,

callbacks = list(

# save best model after every epoch

callback\_model\_checkpoint(file.path(path, "fruits\_checkpoints.h5"), save\_best\_only = TRUE),

# only needed for visualising with TensorBoard

callback\_tensorboard(log\_dir = file.path(path, "fruits\_logs"))

)

)

df\_out <- hist$metrics %>%

{data.frame(acc = .$acc[epochs], val\_acc = .$val\_acc[epochs], elapsed\_time = as.integer(Sys.time()) - as.integer(start))}

**Python**

## Author: D. Kisler - adoptation of R code from https://shirinsplayground.netlify.com/2018/06/keras\_fruits/

from keras.preprocessing.image import ImageDataGenerator

from keras.models import Sequential

from keras.layers import (Conv2D,

Dense,

LeakyReLU,

BatchNormalization,

MaxPooling2D,

Dropout,

Flatten)

from keras.optimizers import RMSprop

from keras.callbacks import ModelCheckpoint, TensorBoard

import PIL.Image

from datetime import datetime as dt

start = dt.now()

# fruits categories

fruit\_list = ["Kiwi", "Banana", "Plum", "Apricot", "Avocado", "Cocos", "Clementine", "Mandarine", "Orange",

"Limes", "Lemon", "Peach", "Plum", "Raspberry", "Strawberry", "Pineapple", "Pomegranate"]

# number of output classes (i.e. fruits)

output\_n = len(fruit\_list)

# image size to scale down to (original images are 100 x 100 px)

img\_width = 20

img\_height = 20

target\_size = (img\_width, img\_height)

# image RGB channels number

channels = 3

# path to image folders

path = "path/to/folder/with/data"

train\_image\_files\_path = path + "fruits-360/Training"

valid\_image\_files\_path = path + "fruits-360/Test"

## input data augmentation/modification

# training images

train\_data\_gen = ImageDataGenerator(

rescale = 1./255

)

# validation images

valid\_data\_gen = ImageDataGenerator(

rescale = 1./255

)

## getting data

# training images

train\_image\_array\_gen = train\_data\_gen.flow\_from\_directory(train\_image\_files\_path,

target\_size = target\_size,

classes = fruit\_list,

class\_mode = 'categorical',

seed = 42)

# validation images

valid\_image\_array\_gen = valid\_data\_gen.flow\_from\_directory(valid\_image\_files\_path,

target\_size = target\_size,

classes = fruit\_list,

class\_mode = 'categorical',

seed = 42)

## model definition

# number of training samples

train\_samples = train\_image\_array\_gen.n

# number of validation samples

valid\_samples = valid\_image\_array\_gen.n

# define batch size and number of epochs

batch\_size = 32

epochs = 10

# initialise model

model = Sequential()

# add layers

# input layer

model.add(Conv2D(filters = 32, kernel\_size = (3,3), padding = 'same', input\_shape = (img\_width, img\_height, channels), activation = 'relu'))

# hiddel conv layer

model.add(Conv2D(filters = 16, kernel\_size = (3,3), padding = 'same'))

model.add(LeakyReLU(.5))

model.add(BatchNormalization())

# using max pooling

model.add(MaxPooling2D(pool\_size = (2,2)))

# randomly switch off 25% of the nodes per epoch step to avoid overfitting

model.add(Dropout(.25))

# flatten max filtered output into feature vector

model.add(Flatten())

# output features onto a dense layer

model.add(Dense(units = 100, activation = 'relu'))

# randomly switch off 25% of the nodes per epoch step to avoid overfitting

model.add(Dropout(.5))

# output layer with the number of units equal to the number of categories

model.add(Dense(units = output\_n, activation = 'softmax'))

# compile the model

model.compile(loss = 'categorical\_crossentropy',

metrics = ['accuracy'],

optimizer = RMSprop(lr = 1e-4, decay = 1e-6))

# train the model

hist = model.fit\_generator(

# training data

train\_image\_array\_gen,

# epochs

steps\_per\_epoch = train\_samples // batch\_size,

epochs = epochs,

# validation data

validation\_data = valid\_image\_array\_gen,

validation\_steps = valid\_samples // batch\_size,

# print progress

verbose = 2,

callbacks = [

# save best model after every epoch

ModelCheckpoint("fruits\_checkpoints.h5", save\_best\_only = True),

# only needed for visualising with TensorBoard

TensorBoard(log\_dir = "fruits\_logs")

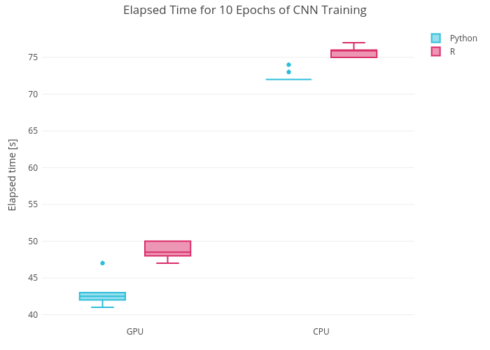
]

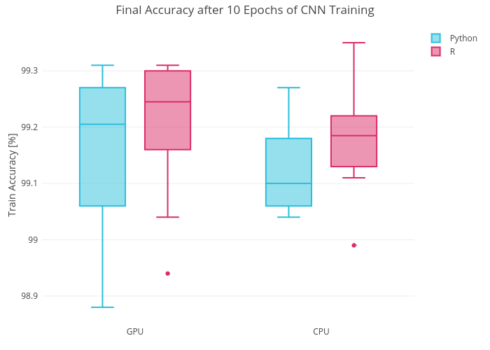
)

df\_out = {'acc': hist.history['acc'][epochs - 1], 'val\_acc': hist.history['val\_acc'][epochs - 1], 'elapsed\_time': (dt.now() - start).seconds}

**Experiment**

The models above were **trained 10 times** with R and Pythons on GPU and CPU, the elapsed time and the final accuracy after 10 epochs were measured. The results of the measurements are presented on the plots below (click the plot to be redirected to [plotly](https://plot.ly) interactive plots).

[](https://datascienceplus.com/wp-content/uploads/2018/06/3.png)

[](https://datascienceplus.com/wp-content/uploads/2018/06/5.png)

From the plots above, one can see that:

* the accuracy of your model doesn’t depend on the language you use to build and train it (the plot shows only train accuracy, but the model doesn’t have high variance and the bias accuracy is around 99% as well).
* even though 10 measurements may be not convincing, but Python would reduce (by up to 15%) the time required to train your CNN model. This is somewhat expected because R uses Python under the hood when executes Keras functions.

Let’s perform unpaired t-test assuming that all our observations are normally distributed.

library(dplyr)

library(data.table)

# fetch the data used to plot graphs

d <- fread('keras\_elapsed\_time\_rvspy.csv')

# unpaired t test:

# t\_score = (mean1 - mean2)/sqrt(stdev1^2/n1+stdev2^2/n2)

d %>%

group\_by(lang, eng) %>%

summarise(el\_mean = mean(elapsed\_time),

el\_std = sd(elapsed\_time),

n = n()) %>% data.frame() %>%

group\_by(eng) %>%

summarise(t\_score = round(diff(el\_mean)/sqrt(sum(el\_std^2/n)), 2))

|  |  |
| --- | --- |
| **eng** | **t\_score** |
| cpu | 11.38 |
| gpu | 9.64 |

T-score reflects a significant difference between the time required to train a CNN model in R compared to Python as we saw on the plot above.

**Summary**

Building and training CNN model in R using Keras is as “easy” as in Python with the same coding logic and functions naming convention. Final accuracy of your Keras model will depend on the neural net architecture, hyperparameters tuning, training duration, train/test data amount etc., but not on the programming language you would use for your DS project. Training a CNN Keras model in Python may be up to 15% faster compared to R