

# Deep Learning



## Computer Vision

### Keras



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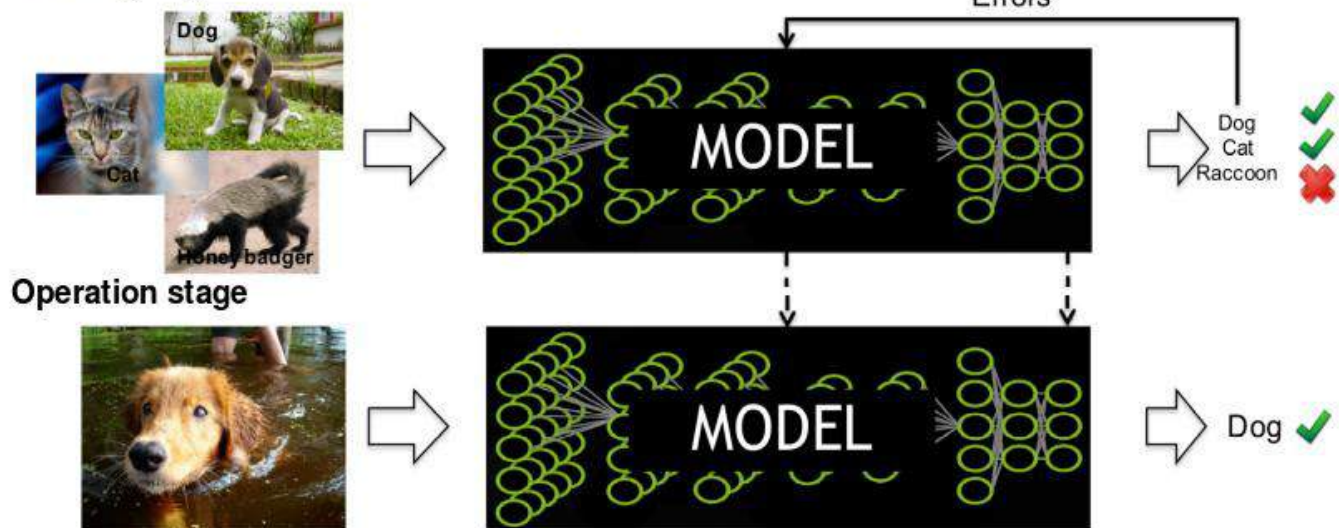
Roberto Valle ([rvalle@fi.upm.es](mailto:rvalle@fi.upm.es) (<mailto:rvalle@fi.upm.es>))

# Machine Learning Life Cycle

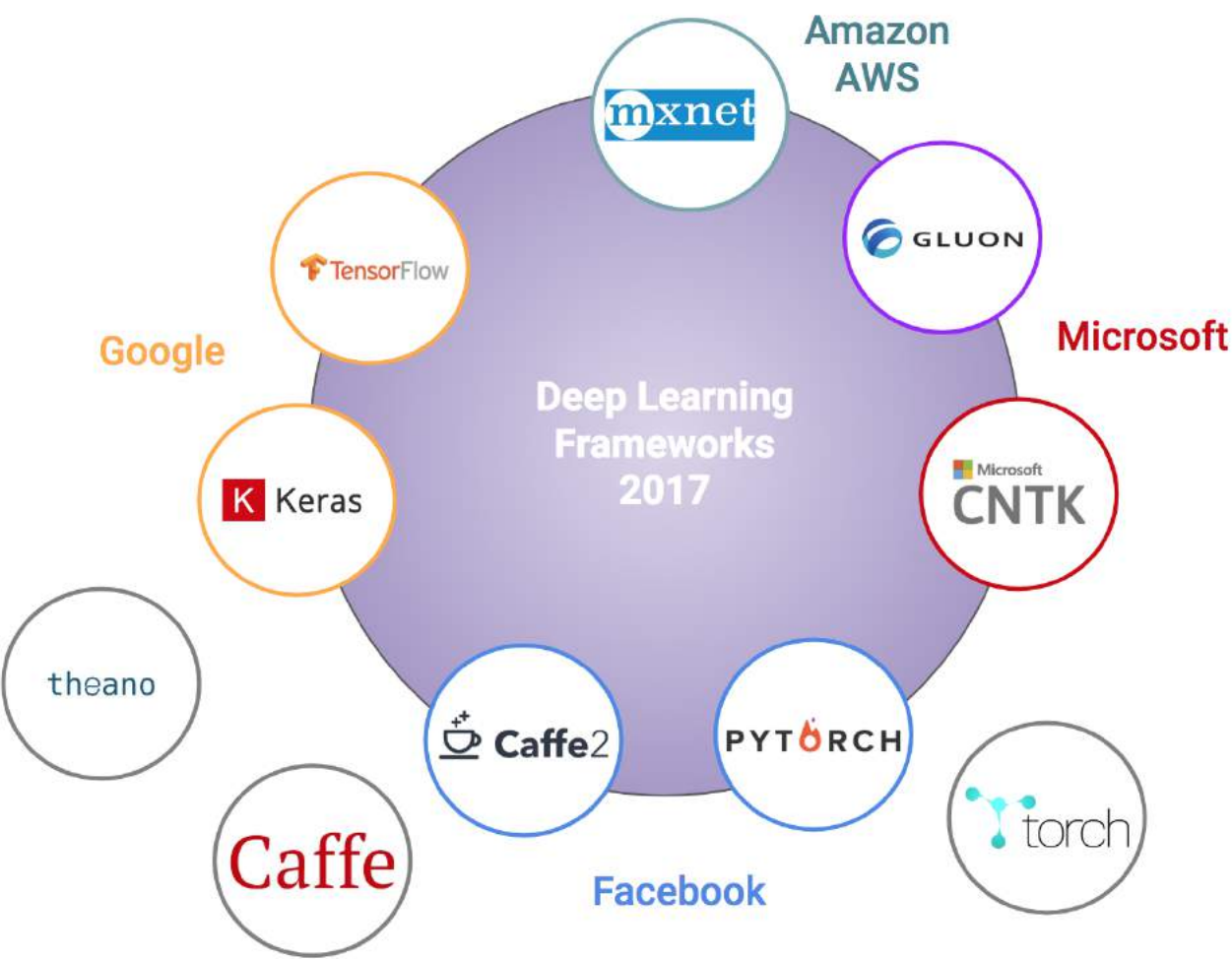
How computers learn to recognize objects.

- **Training phase:** We train a machine learning algorithm using a data set and their corresponding labels.
- **Prediction phase:** We use the trained model to predict labels of unseen images.

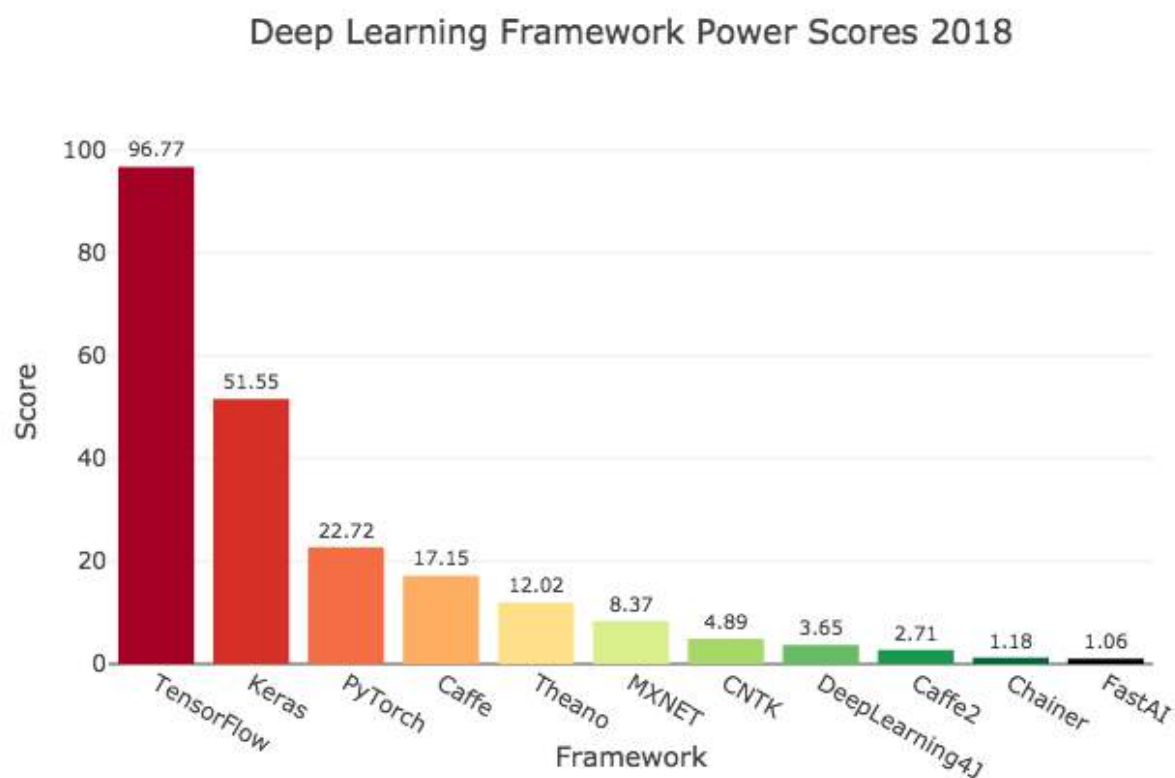
## Training stage



# Deep Learning Frameworks



Keras has broad adoption in the industry and the research community



## Introducing Keras

- Keras is a high-level neural networks API, written in Python and capable of running on top of TensorFlow, CNTK, or Theano <https://keras.io/> (<https://keras.io/>).
- It was developed with a focus on enabling fast experimentation.
- Runs seamlessly on CPU and GPU.
- **User friendliness** Keras is an API designed for human beings, not machines.
- **Modularity** A model is understood as a sequence or a graph of standalone, fully-configurable modules that can be plugged together with as few restrictions as possible.
- **Easy extensibility** New modules are simple to add (as new classes and functions).
- **Work with Python** Models are described in Python code (compatible with Python 2.7-3.6), which is compact, easier to debug, and allows for ease of extensibility.

Try Keras: <https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/guide/keras.ipynb> (<https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/guide/keras.ipynb>).

### What is a "backend"?

Keras is a model-level library, providing high-level building blocks for developing deep learning models. It does not handle itself low-level operations such as tensor products, convolutions and so on. Instead, it relies on a specialized, well-optimized tensor manipulation library to do so, serving as the "backend engine" of Keras.

At this time, Keras has three backend implementations available: the TensorFlow backend, the Theano backend, and the CNTK backend.

- TensorFlow is an open-source symbolic tensor manipulation framework developed by Google.
- Theano is an open-source symbolic tensor manipulation framework developed by LISA Lab at Université de Montréal.
- CNTK is an open-source toolkit for deep learning developed by Microsoft.

## Keras main components

Keras is comprised of several components, some of which the user should be aware of:

- The core data structure of Keras is a **model**, a way to organize layers.
- The simplest type of model is the Sequential model, a linear stack of layers. For more complex architectures, you should use the Keras functional API, which allows to build arbitrary graphs of layers.
- Stacking layers is as easy as `.add()`
- The model needs to know what input shape it should expect. For this reason, the first layer in a Sequential model (and only the first, because following layers can do automatic shape inference) needs to receive information about its input shape.

In [1]:

```
from keras.models import Sequential
from keras.layers import Dense, Activation, Flatten

model = Sequential()
model.add(Flatten(input_shape=(32, 32, 3)))
model.add(Dense(units=64, activation='relu'))
model.add(Dense(units=10))
model.add(Activation('softmax'))
```

Using TensorFlow backend.

## Keras main components

Keras is comprised of several components, some of which the user should be aware of:

- Before training a model, you need to **configure** the learning process, which is done via the compile method.
- It receives three arguments:
  - *Optimizer*: This object specifies the training procedure.
  - *Loss function*: The function to minimize during optimization.
  - *Metrics*: Used to monitor training.

In [2]:

```
# For a multi-class classification problem
model.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['accuracy'])
model.summary()

# For custom metrics
import keras.backend as K
def categorical_accuracy(y_true, y_pred):
    return K.cast(K.equal(K.argmax(y_true, axis=-1), K.argmax(y_pred, axis=-1)), K.floatx())
model.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['accuracy', categorical_accuracy])
```

Layer (type)	Output Shape	Param #
flatten_1 (Flatten)	(None, 3072)	0
dense_1 (Dense)	(None, 64)	196672
dense_2 (Dense)	(None, 10)	650
activation_1 (Activation)	(None, 10)	0
Total params: 197,322		
Trainable params: 197,322		
Non-trainable params: 0		

## Keras main components

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- Fortunately, the `keras.datasets` module already includes methods to load and fetch popular reference **data sets**.
- Here's the list of available datasets:
  - Boston Housing (regression)
  - CIFAR10 (classification of 10 image labels)
  - CIFAR100 (classification of 100 image labels)
  - MNIST (classification of 10 digits)
  - Fashion-MNIST (classification of 10 fashion categories)
  - IMDB Movie Reviews (binary text classification)
  - Reuters News (multiclass text classification)

In [3]:

```
# Load CIFAR-10 data set
from keras.datasets import cifar10
(x_train, y_train), (x_test, y_test) = cifar10.load_data()

x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255.0
x_test /= 255.0

from keras.utils import np_utils
y_train = np_utils.to_categorical(y_train, 10)
y_test = np_utils.to_categorical(y_test, 10)
```

## Keras main components

Keras is comprised of several components, some of which the user should be aware of:

- Keras models are trained on Numpy arrays of input data and labels. For **training** a model, you will typically use the `fit()` function
  - *Epoch*: one iteration over the entire input data (this is done in smaller batches).
  - *Batch size*: When passed NumPy data, the model slices the data into smaller batches and iterates over these batches during training.
  - *Validation data*: When prototyping a model, you want to easily monitor its performance on some validation data.

In [4]:

```
# Train the model, iterating on the data in batches of 32 samples
history = model.fit(x_train, y_train, epochs=10, batch_size=32)
```

```
Epoch 1/10
50000/50000 [=====] - 5s 104us/step - loss: 2.0985 - acc: 0.2078 - categorical_accuracy: 0.2078
Epoch 2/10
50000/50000 [=====] - 5s 91us/step - loss: 1.9938 - acc: 0.2449 - categorical_accuracy: 0.2449
Epoch 3/10
50000/50000 [=====] - 5s 90us/step - loss: 1.9692 - acc: 0.2493 - categorical_accuracy: 0.2493
Epoch 4/10
50000/50000 [=====] - 4s 89us/step - loss: 1.9570 - acc: 0.2520 - categorical_accuracy: 0.2520
Epoch 5/10
50000/50000 [=====] - 4s 86us/step - loss: 1.9510 - acc: 0.2559 - categorical_accuracy: 0.2559
Epoch 6/10
50000/50000 [=====] - 4s 87us/step - loss: 1.9460 - acc: 0.2551 - categorical_accuracy: 0.2551
Epoch 7/10
50000/50000 [=====] - 5s 93us/step - loss: 1.9408 - acc: 0.2536 - categorical_accuracy: 0.2536
Epoch 8/10
50000/50000 [=====] - 4s 88us/step - loss: 1.9371 - acc: 0.2590 - categorical_accuracy: 0.2590
Epoch 9/10
50000/50000 [=====] - 5s 91us/step - loss: 1.9344 - acc: 0.2562 - categorical_accuracy: 0.2562
Epoch 10/10
50000/50000 [=====] - 4s 89us/step - loss: 1.9335 - acc: 0.2567 - categorical_accuracy: 0.2567
```

## Keras main components

Keras is comprised of several components, some of which the user should be aware of:

- For **evaluation** mode you have to use the `evaluate()` function. Its output is accuracy or loss, not prediction to your input data.
- Use `predict()` to **predict** the output of the last layer in inference for the data provided. Its output is target value, predicted from your input data.
- So if you use `model.predict` and then compute the metrics yourself, the computed metric value should turn out to be the same as `model.evaluate`.

In [5]:

```
accuracy = model.evaluate(x_test, y_test, batch_size=32)
print(accuracy)
print(model.metrics_names)
```

```
10000/10000 [=====] - 0s 48us/step
[1.9546743999481202, 0.2591, 0.2591]
['loss', 'acc', 'categorical_accuracy']
```



In [7]:

```
prediction = model.predict(x_test, batch_size=32)
print(y_test[5])
print(prediction[5])
import numpy as np
print(np.argmax(prediction[5]))
```

```
[ 0.  0.  0.  0.  0.  0.  1.  0.  0.  0.]
[ 0.01300764  0.08614522  0.08283562  0.13504931  0.11599413  0.0901209
6
 0.26814824  0.12336987  0.01480679  0.07052226]
6
```

## Prerequisites

### CPU mode installation

```
pip install tensorflow keras
```

### GPU vs CPU compilation

Check your NVIDIA drivers compatibility (CUDA 9.0 requires 384.x or higher).

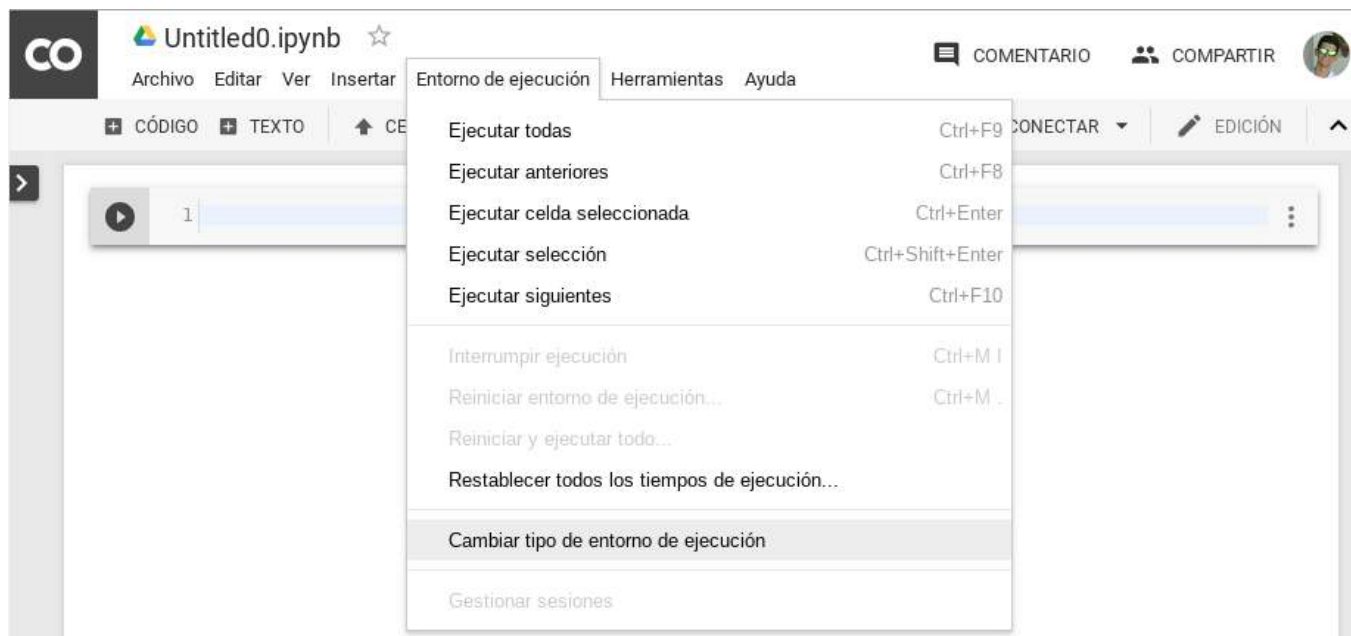
```
nvidia-smi
```

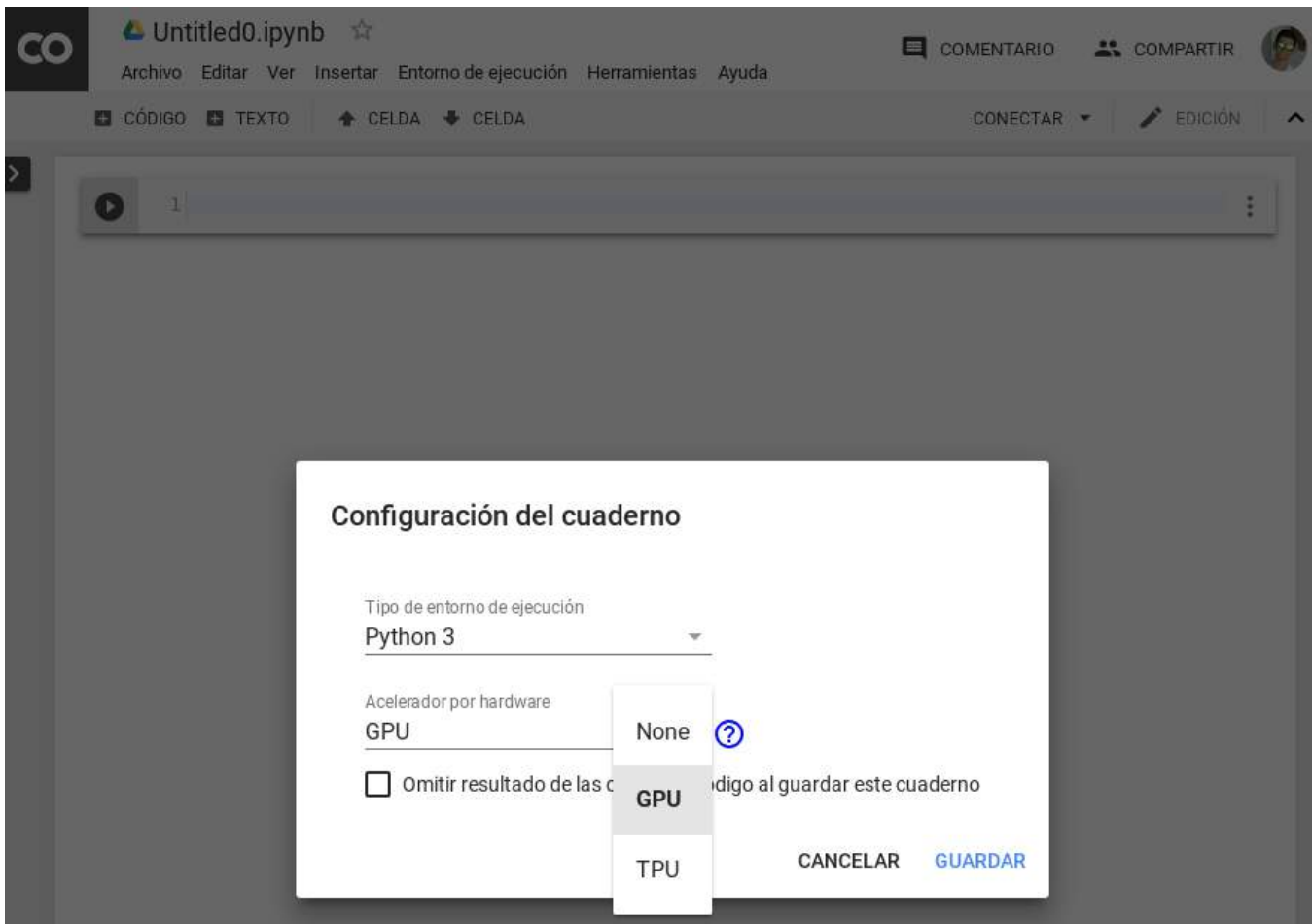
CUDA-9.0 (<https://developer.nvidia.com/cuda-toolkit> (<https://developer.nvidia.com/cuda-toolkit>)) and cuDNN ( $\geq 7.0$ ) (<https://developer.nvidia.com/cudnn> (<https://developer.nvidia.com/cudnn>)) are required for GPU acceleration mode.

```
nvcc --version
pip install tensorflow-gpu keras
```

# Keras - Google Colab

- Google Colaboratory, Google's free cloud service for AI developers, provides a free Tesla K80 GPU for up to 12 hours at a time.
- Colab is working on your own Google Drive.
- Create a new notebook via <https://colab.research.google.com/> (<https://colab.research.google.com/>).
- Keras + Tensorflow GPU has been already installed.






# Keras - Google Cloud

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School Email

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https://console.cloud.google.com/education

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Visión general

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Exportación de la facturación

Informes

Visión general

ID de la cuenta de facturación: 015925-F1D161-77BDE3

Créditos

50,00 \$

Créditos restantes

De 50,00 \$

306

Días restantes

Caduca el 1 sept. 2019

Proyectos vinculados con esta cuenta de facturación

No hay proyectos vinculados con esta cuenta de facturación.

Visión por Computador


CAMBIAR NOMBRE CUENTA FACTURACIÓN

- **Create Project**

In the Google Developers Console, click Select a project > Create a project.

Google Cloud Platform

## Nuevo proyecto



Te quedan 23 projects en la cuota. Solicita un aumento o elimina proyectos.  
[Más información](#)  
[MANAGE QUOTAS](#)

Nombre del proyecto \*

Proyecto Estudiante

?

ID del proyecto: proyecto-estudiante. No se puede cambiar más adelante. [EDITAR](#)

Cuenta de facturación \*

Visión por Computador

▼

Todos los cargos de este proyecto se realizarán en la cuenta que selecciones aquí.

Ubicación \*

Ninguna organización

[EXPLORAR](#)

Carpeta u organización principal

CREAR

CANCELAR





**IMPORTANT:** Make sure you stop your instances! Don't forget to stop your instance when you are done (by clicking on the stop button at the top of the page showing your instances), otherwise you will run out of credits and that will be very sad :(



- **Using Jupyter Notebook with Google Cloud**

Many of the assignments will involve using Jupyter Notebook. Below, we discuss how to run Jupyter Notebook from your instance and connect to it with your local browser.

- Getting a Static IP Address
- Adding a firewall rule
- Launching and connecting to Jupyter Notebook

## Getting a Static IP Address

Change the External IP address of your instance to be static. To do this, click on the 3 line icon next to the Google Cloud Platform button on the top left corner of your screen, go to VPC network and External IP addresses (see screenshot below).

Google Cloud Platform

Computer Vision UPM

Red de VPC

Direcciones IP externas

Reglas de cortafuegos

Rutas

Emparejamiento entre redes ...

VPC compartida

Reservar una dirección estática

Nombre

gpu-ip

Descripción (Opcional)

Static IP for the GPU instance

Nivel de servicio de red

Premium (nivel de proyecto actual, [cambiar](#))

Estándar (us-west1)

El nivel Standard no está disponible en la región seleccionada, pero sí lo está actualmente en us-central1, us-east1, europe-west1, europe-west3, asia-east1.

Versión de IP

IPv4

IPv6

Tipo

Regional

Global (se usa con las reglas de reenvío globales. [Más información](#))

Región

us-west1

Vinculado a

ubuntu-gpu

Reservar

Cancelar

REST o línea de comandos equivalentes

To have a static IP address, change Type from Ephemeral to Static. Enter your preferred name for your static IP, ours is gpu-ip (see screenshot below). And click on Reserve.

Direcciones IP externas

RESERVAR DIRECCIÓN ESTÁTICA

ACTUALIZAR

MOSTRAR PANEL DE INFORMACIÓN

Filtrar direcciones

<input checked="" type="checkbox"/>	Nombre	Dirección externa	Región	Tipo ▾	Versión	Usada por	Nivel de red ⓘ	Etiquetas
<input checked="" type="checkbox"/>	gpu-ip	35.203.186.243	us-west1	<div>Estática</div> <div>Efímera</div>	IPv4	Instancia de VM <u>ubuntu-gpu</u> (Zona b)	Premium	Cambiar

Remember to release the static IP address when you are done because according to this page (<https://jeffdelaney.me/blog/running-jupyter-notebook-google-cloud-platform/>) Google charges a small fee for unused static IPs.

## Adding a firewall rule

One last thing you have to do is adding a new firewall rule allowing TCP access to a particular port number. The default port we use for Jupyter is 8888. On the menu that pops up on the left column, go to VPC network and Firewall rules. Click on the blue Create Firewall Rule button. Enter whatever name you want. Select "All instances in the network" for Targets (if the menu item exists). Enter 0.0.0.0/0 for Source IP ranges and tcp: 8888 for Specified protocols and ports where 8888 is the number you used above. Click on the blue Create button. See the screenshot below.

Google Cloud Platform Computer Vision UPM

Red de VPC

← Crear una regla de cortafuegos

Las reglas de cortafuegos controlan el tráfico entrante o saliente de una instancia. De forma predeterminada, se bloquea el tráfico entrante que sea ajeno a tu red. [Más información](#)

**Nombre** ?

gpu-firewall

**Descripción** (Opcional)

**Registros**

Activar los registros del cortafuegos puede generar un gran número de registros, lo que podría aumentar los costes de Stackdriver. [Más información](#)

☐ Activar

☒ Desactivar

**Red** ?

default

**Prioridad** ?

La prioridad puede estar entre 0 y 65535. [Comprobar la prioridad de otras reglas de cortafuegos](#)

1000

**Dirección del tráfico** ?

☒ Entrada

☐ Salida

**Acción tras coincidencia** ?

☒ Permitir

☐ Denegar

**Destinos** ?

Todas las instancias de la red

**Filtro de origen** ?

Intervalos de IPs

**Intervalos de IPs de origen** ?

0.0.0.0/0

**Filtro de origen secundario** ?

Ninguno

**Protocolos y puertos** ?

☐ Permitir todos

☒ Protocolos y puertos especificados

☒ tcp : 8888

☐ udp : todos

☐ Otros protocolos

Protocolos separados por comas, p. ej.: ah, sctp

## Launching and connecting to Jupyter Notebook

After you ssh into your instance, install Jupyter notebook and export `PATH=$PATH:~/local/bin`

```
bobetocalo@ubuntu-gpu: ~ - Google Chrome
https://ssh.cloud.google.com/projects/proyecto-estudiante/zones/us-west1-b/instances/ubuntu-gpu?authuser=0&hl=es&projectNumber=812364884794
bobetocalo@ubuntu-gpu:~$ pip3 install jupyter
Collecting jupyter
  Using cached https://files.pythonhosted.org/packages/83/df/0f5dd132200728a86190397e1ea87cd76244e42d39ec5e88efd25b2abd7e/jupyter-1.0.0-py2.py3-none-any.whl
Collecting jupyter-console (from jupyter)
  Using cached https://files.pythonhosted.org/packages/cb/ee/6374ae8c21b7d0847f9c3722dcdfac986b8e54fa9ad9ea66e1eb6320d2b8/jupyter_console-6.0.0-py2.py3-none-any.whl
Collecting qtconsole (from jupyter)
  Using cached https://files.pythonhosted.org/packages/37/22/0d8474f78a8c421d485ac2339de7c871d535160f09f170de90c8185b87c4/qtconsole-4.4.2-py2.py3-none-any.whl
Collecting notebook (from jupyter)
  Using cached https://files.pythonhosted.org/packages/44/16/9f108b675828c4117cfe72d8d0f97094163c40584e40c46ec48a1e862693/notebook-5.7.0-py2.py3-none-any.whl
Collecting ipykernel (from jupyter)
  Using cached https://files.pythonhosted.org/packages/d8/b0/f0be5c5ab335196f5cce96e5b889a4fcf5bfe462eb0acc05cd7e2caf65eb/ipykernel-5.1.0-py3-none-any.whl
Collecting ipywidgets (from jupyter)
  Using cached https://files.pythonhosted.org/packages/30/9a/a008c7b1183fac9e52066d80a379b3c64eab535bd9d86cdc29a0b766fd82/ipywidgets-7.4.2-py2.py3-none-any.whl
```

Run `jupyter notebook --generate-config` and edit the generated file with all the defaults commented out

```
https://ssh.cloud.google.com/projects/computer-vision-upm/zones/us-west1-b/instances/ubuntu-8cpus-30gb?authuser=0&hl=es&projectNumber=800808182577
# Configuration file for jupyter-notebook.

c = get_config()
# Kernel config
c.IPKernelApp.pylab = 'inline' # if you want plotting support always in your notebook
# Notebook config
c.NotebookApp.ip = '0.0.0.0'
c.NotebookApp.open_browser = False #so that the ipython notebook does not opens up a browser by default
c.NotebookApp.port = 8888

#-----
# Application(SingletonConfigurable) configuration
#-----

# This is an application.

# The date format used by logging formatters for %(asctime)s
c.Application.log_datefmt = '%Y-%m-%d %H:%M:%S'
```

To run the jupyter notebook, just type the following command in the ssh window you are in: `jupyter-notebook --no-browser`

```
https://ssh.cloud.google.com/projects/proyecto-estudiante/zones/us-west1-b/instances/ubuntu-gpu?authuser=0&hl=es&projectNumber=812364884794
bobetocalo@ubuntu-gpu:~$ jupyter-notebook --no-browser
[I 15:50:53.550 NotebookApp] Serving notebooks from local directory: /home/bobetocalo
[I 15:50:53.550 NotebookApp] The Jupyter Notebook is running at:
[I 15:50:53.551 NotebookApp] http://(ubuntu-gpu or 127.0.0.1):8888/?token=f3f383985e8a8e30bc4964e539598007fe59940f0e6ec0c5
[I 15:50:53.551 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).

Copy/paste this URL into your browser when you connect for the first time,
to login with a token:
http://(ubuntu-gpu or 127.0.0.1):8888/?token=f3f383985e8a8e30bc4964e539598007fe59940f0e6ec0c5
```

You will get this IP address on terminal, block the whole IP addresses (with the token as well), it will automatically “cut” it. Paste it on our web browser, and change “0.0.0.0” with our VM static external IP.

