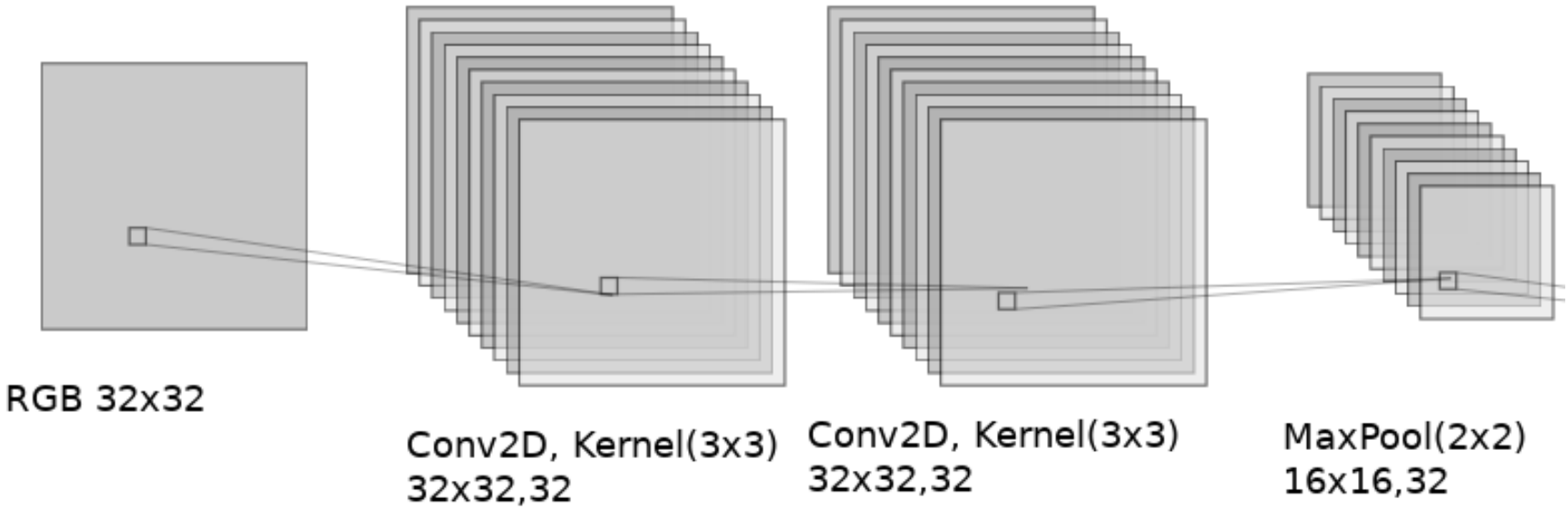
CNN for Cifar-10 e Cifar-100 Classification on *Coral Edge TPU USB Accelerator* and *ST Cloud JAM*

March 2020

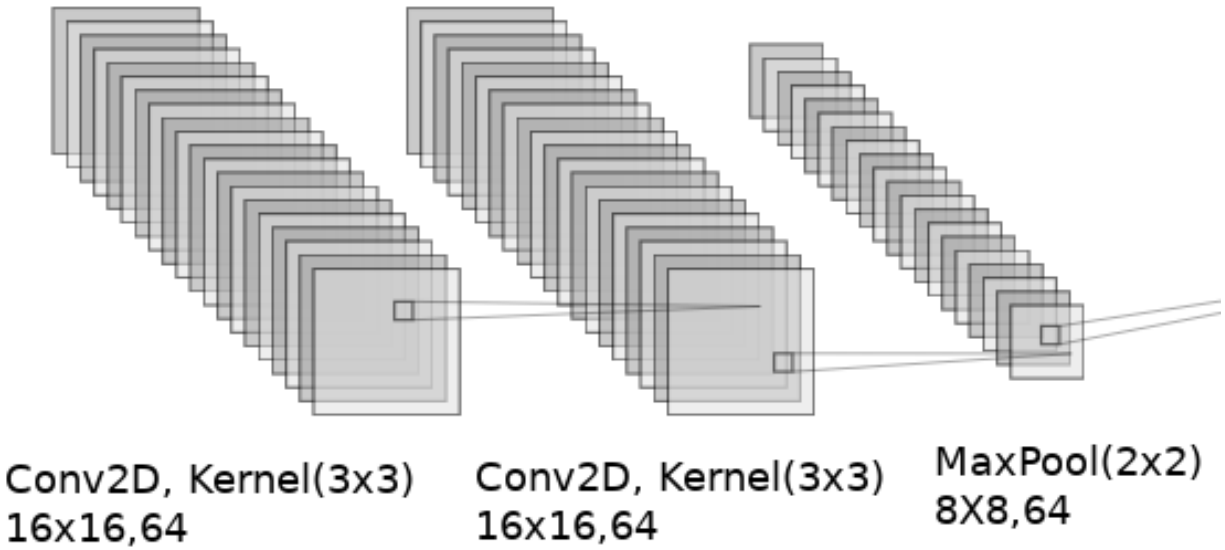
CNN for Cifar-10 classification on computer

Neural Network architecture



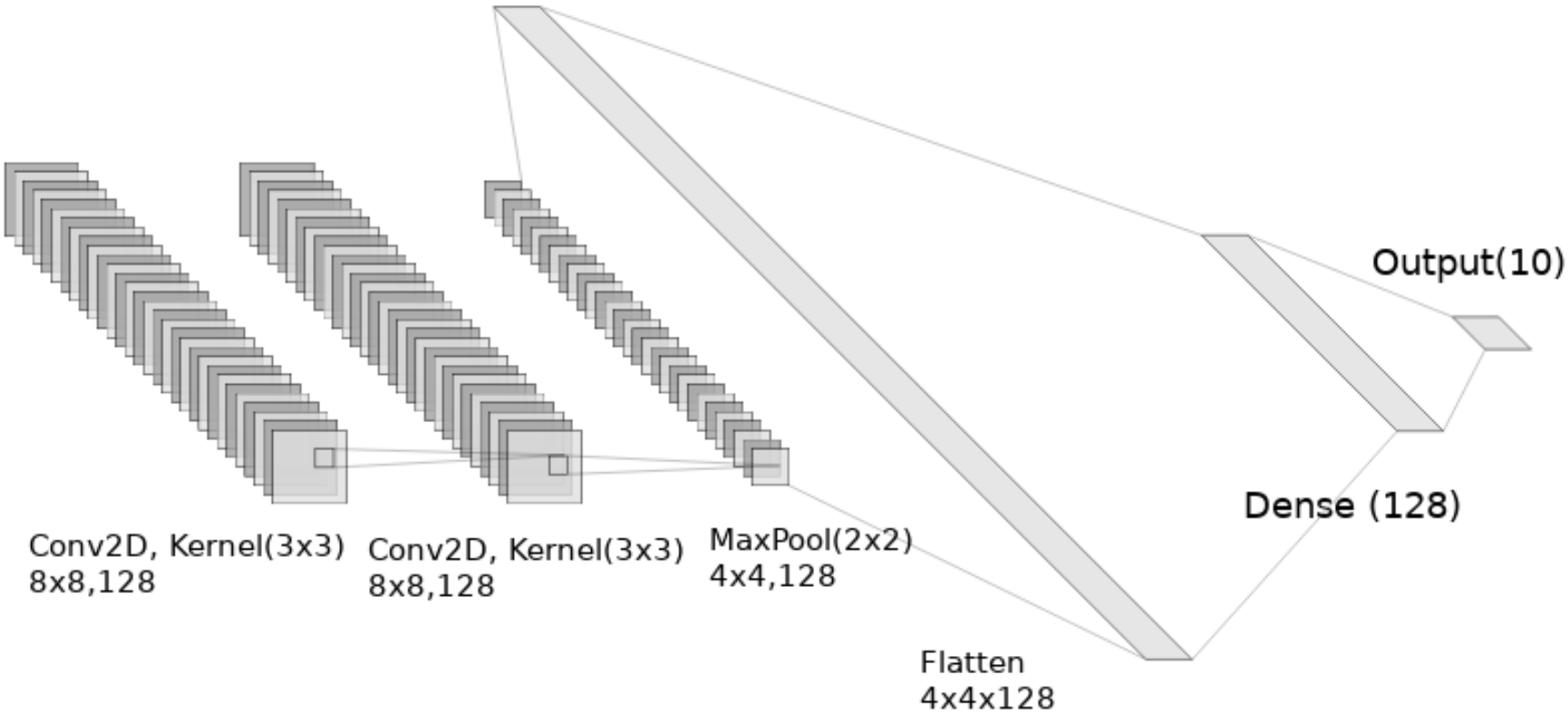
CNN for Cifar-10 classification on computer

Neural Network architecture



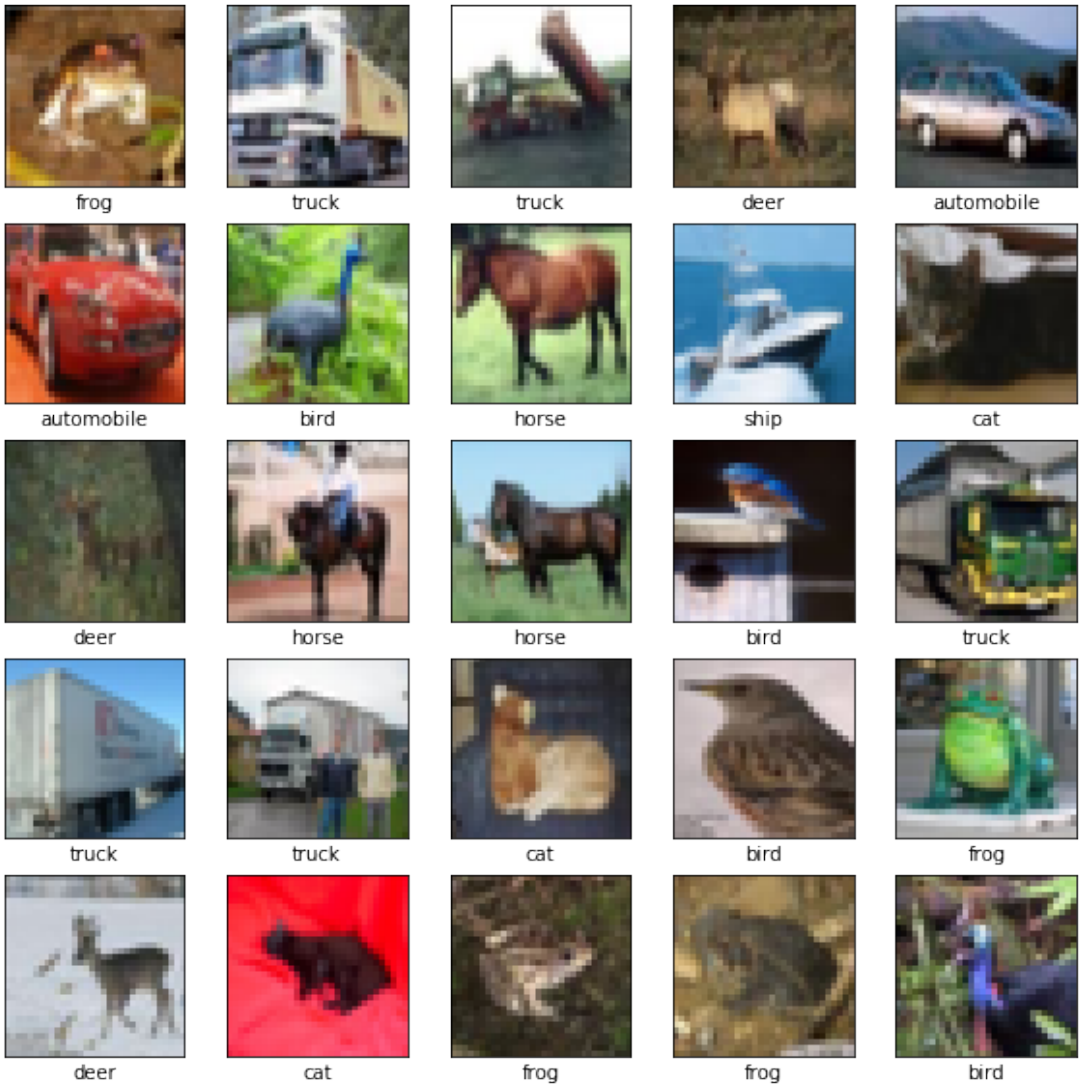
CNN for Cifar-10 classification on computer

Neural Network architecture



Cifar-10 random images

Stampa di pictures random



CNN for Cifar-10 classification on computer

Data Agumentation

```
datagen = ImageDataGenerator(
^^Irotation_range=15,
^^Iwidth_shift_range=.1,
^^Iheight_shift_range=.1,
^^Ihorizontal_flip=True,
^^Izoom_range=0.5)
```

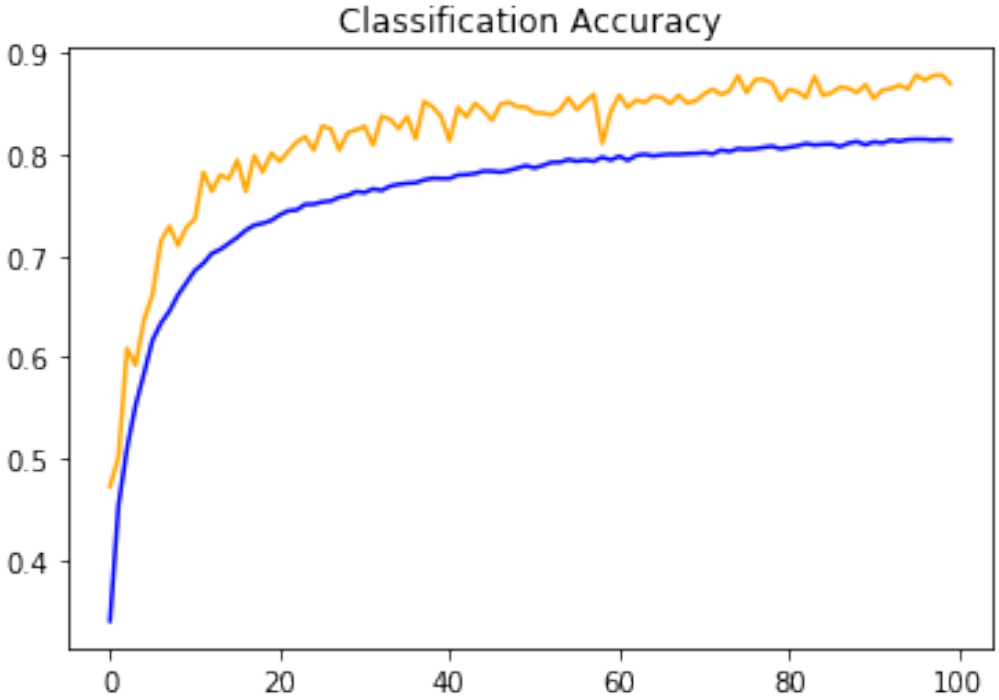
CNN for Cifar-10 classification on computer

Training hyperparameters

```
model.compile(loss=keras.losses.categorical_crossentropy,
    optimizer=keras.optimizers.Adam(),metrics=['accuracy'])
^^I
```

CNN for Cifar-10 classification on computer

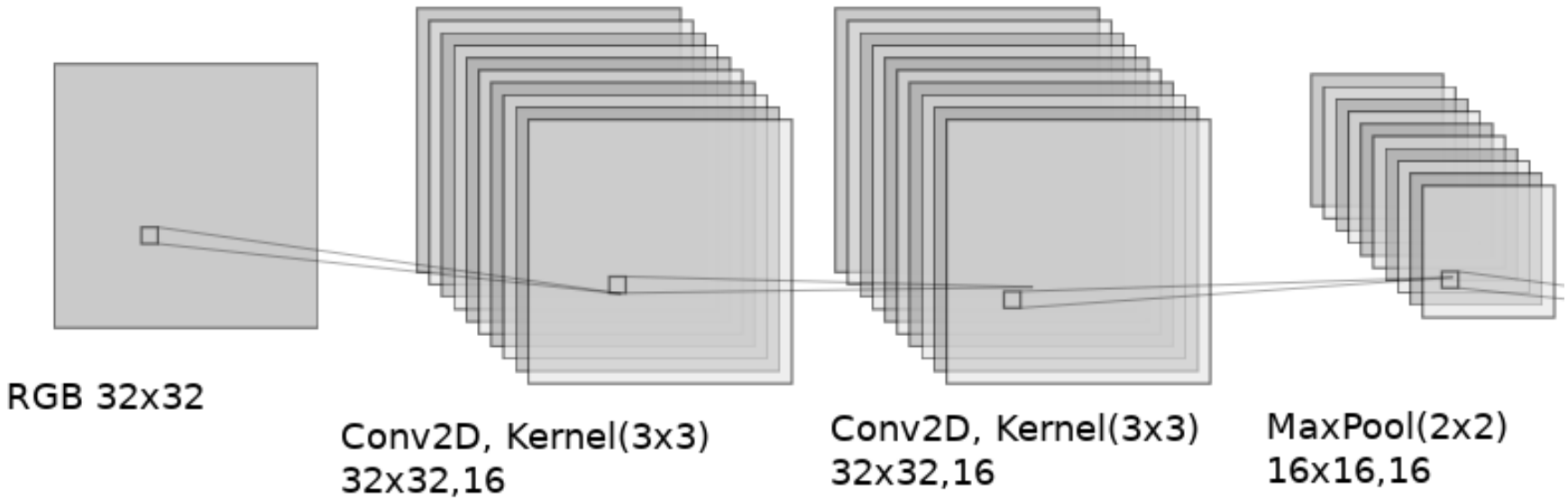
Accuracy




```
Epoch 100/100
782/782 [==============================] - 31s 40ms/step -
    loss: 0.5471 - acc: 0.8146 - val_loss: 0.3975 - val_acc:
     0.8701
```

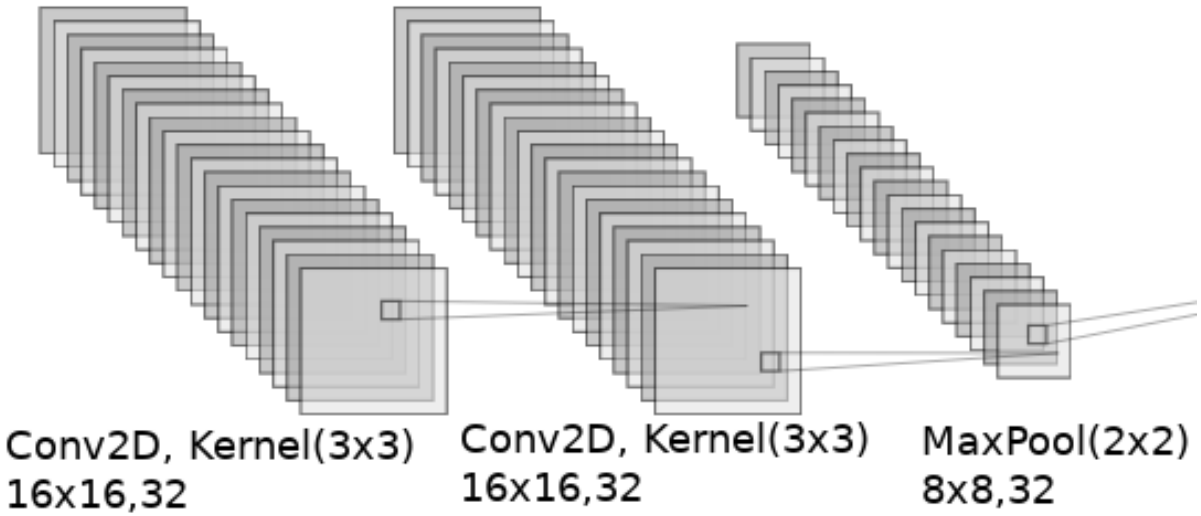
CNN for Cifar-10 classification on ST Cloud JAM

Neural Network architecture



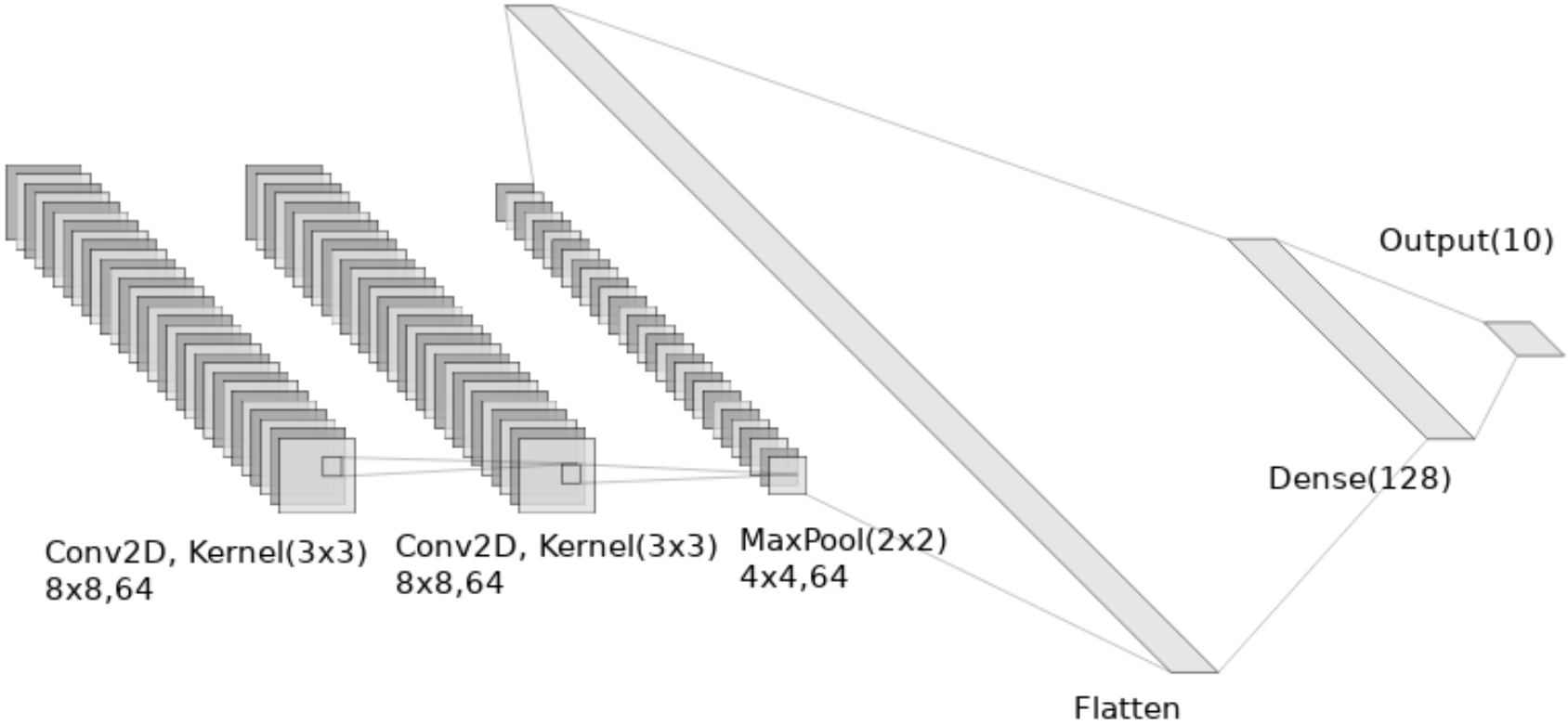
CNN for Cifar-10 classification on ST Cloud JAM

Neural Network architecture



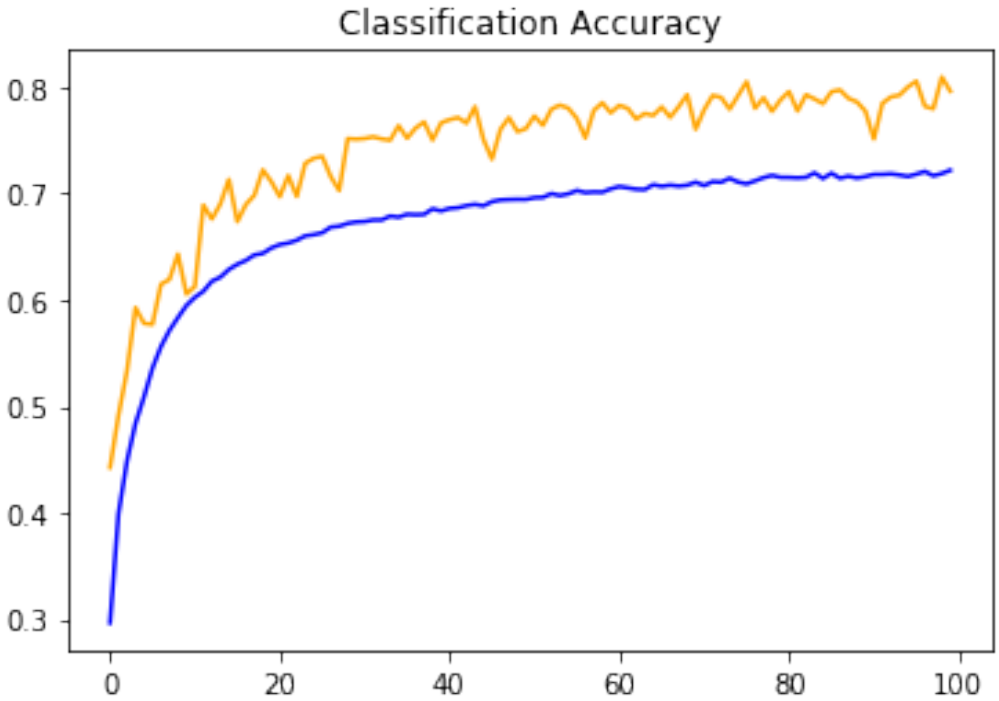
CNN for Cifar-10 classification on ST Cloud JAM

Neural Network architecture



CNN for Cifar-10 classification on ST Cloud JAM

Accuracy




```
^^IEpoch 100/100
^^I782/782 [==============================] - 43s 55ms/step
    - loss: 0.8155 - acc: 0.7220 - val_loss: 0.5932 -
    val_acc: 0.7963
^^I
```

Test CNN con Cifar-10 su ST Cloud JAM

Validation on target of the Neural Network

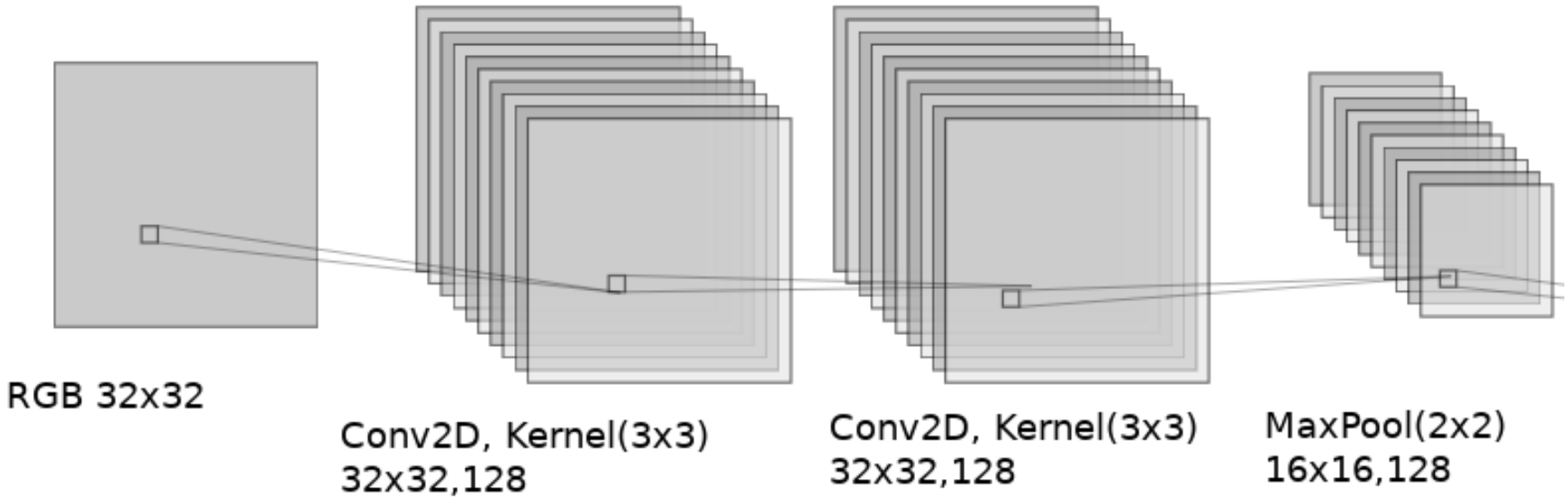
The network is imported without weights compression. The L2R error betwen the results on host (computer) and target is in the order of 10^-6

```
acc=100.00%, rmse=0.0000, mae=0.0000
10 classes (1000 samples)
-------------------------------------------------------
C0          0    .    .    .    .    .    .    .    .
C1          .  508    .    .    .    .    .    .    .
C2          .    .    0    .    .    .    .    .    .
C3          .    .    .    0    .    .    .    .    .
C4          .    .    .    .    0    .    .    .    .
C5          .    .    .    .    .   14    .    .    .
C6          .    .    .    .    .    .    0    .    .
C7          .    .    .    .    .    .    .    5    .
C8          .    .    .    .    .    .    .    .    2
C9          .    .    .    .    .    .    .    .    .

Evaluation report (summary)
-------------------------------------------------
Mode                    acc        rmse       mae
-------------------------------------------------
X-cross #1              100.0%     0.000001   0.000000
L2r error : 4.15037266e-06 (expected to be < 0.01)
```

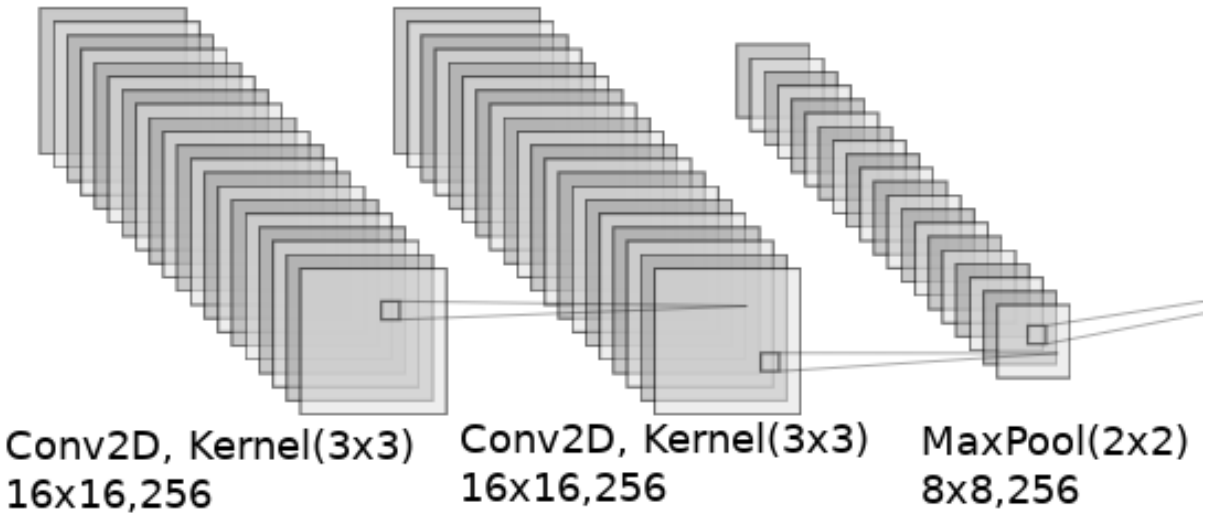
CNN for Cifar-100 classification on computer

Neural Network architecture



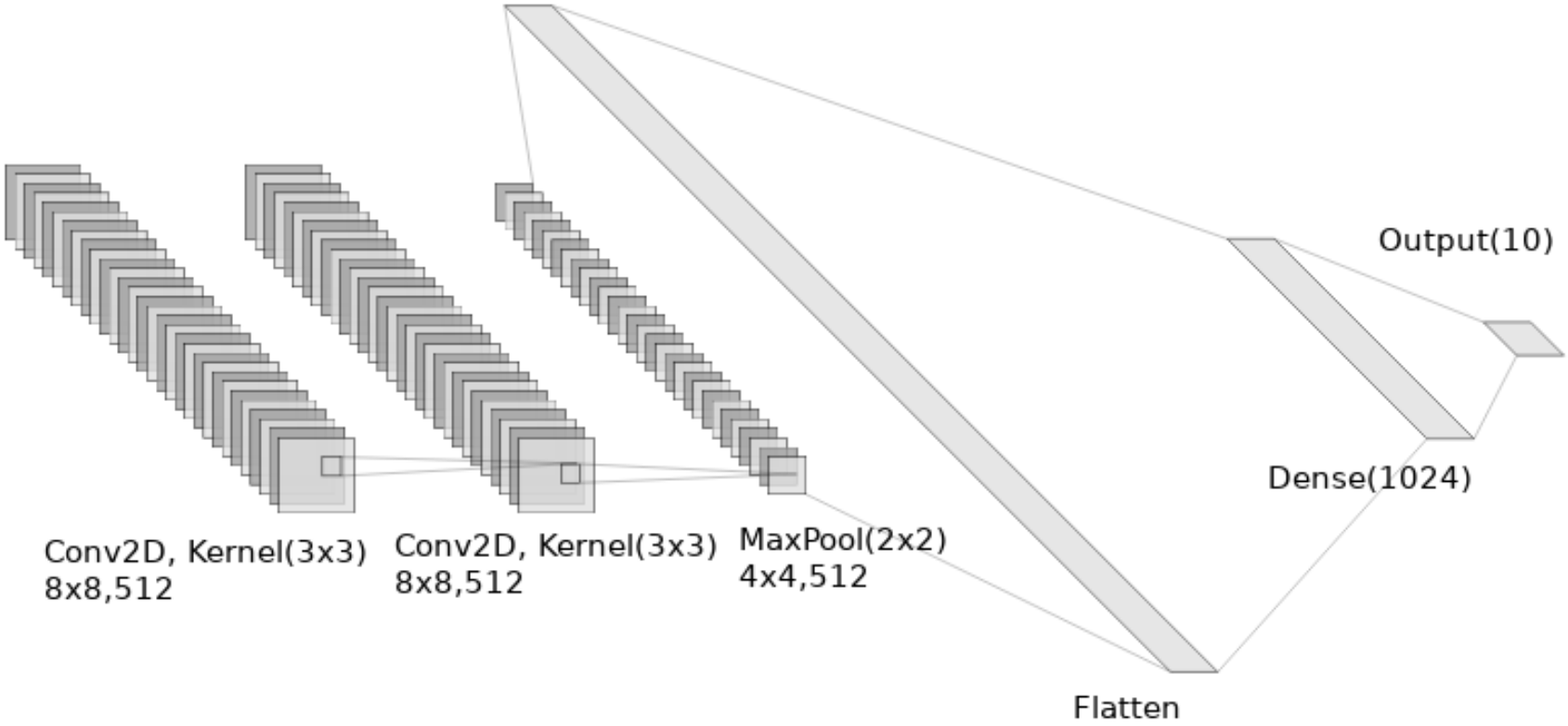
CNN for Cifar-100 classification on computer

Neural Network architecture

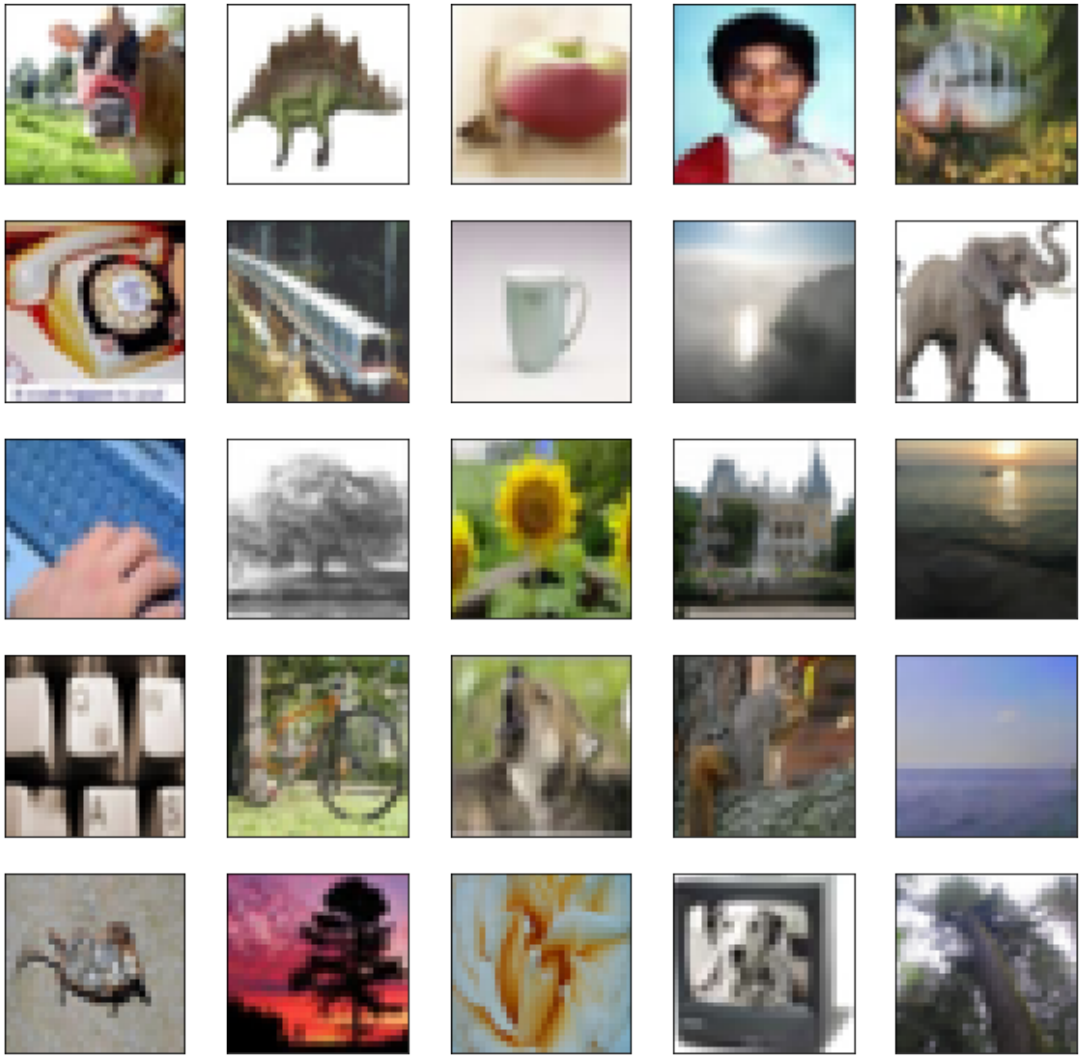


CNN for Cifar-100 classification on computer

Neural Network architecture

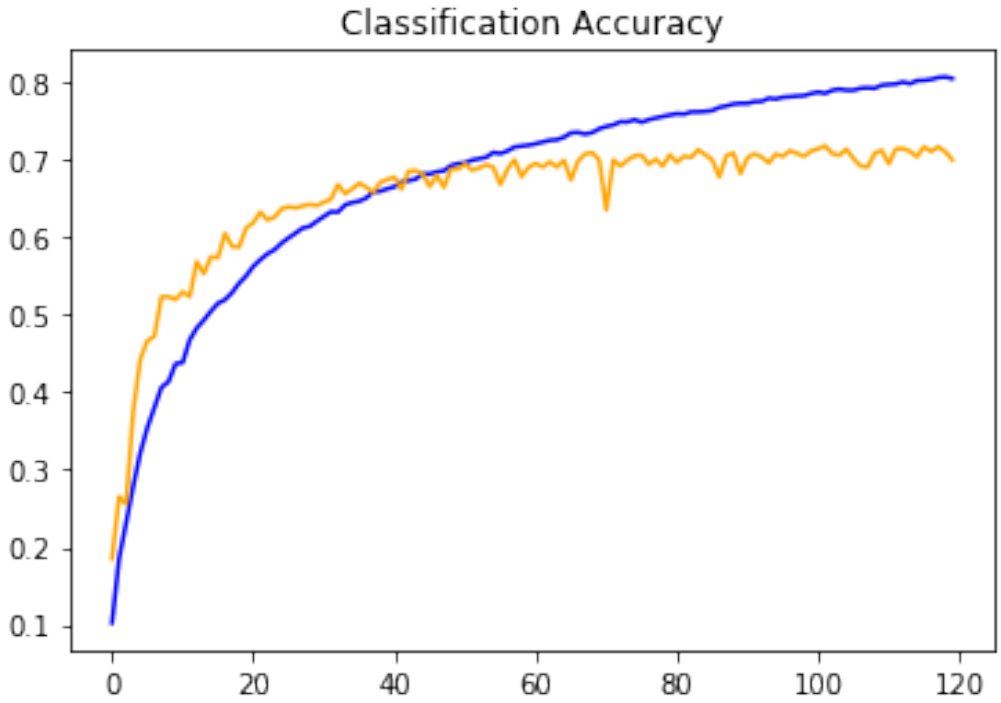


Cifar-100 random images



CNN for Cifar-100 classification on computer

Accuracy




```
Epoch 120/120
782/782 [==============================] - 50s 64ms/step -
    loss: 0.6304 - acc: 0.8049 - val_loss: 1.2676 - val_acc:
     0.7001
```

Test CNN con Cifar-100 su ST Cloud JAM

Validation on target of the Neural Network

The network is imported without weights compression. The L2R error betwen the results on host (computer) and target is in the order of $10^{-}6$

```
Running with inputs (1000, 32, 32, 3)..

acc=100.00%, rmse=0.0000, mae=0.0000



Evaluation report (summary)
-------------------------------------------------------
Mode                        acc         rmse        mae
-------------------------------------------------------
X-cross #1                  100.0%      0.000000    0.000000

L2r error : 1.32934053e-06 (expected to be < 0.01)
```

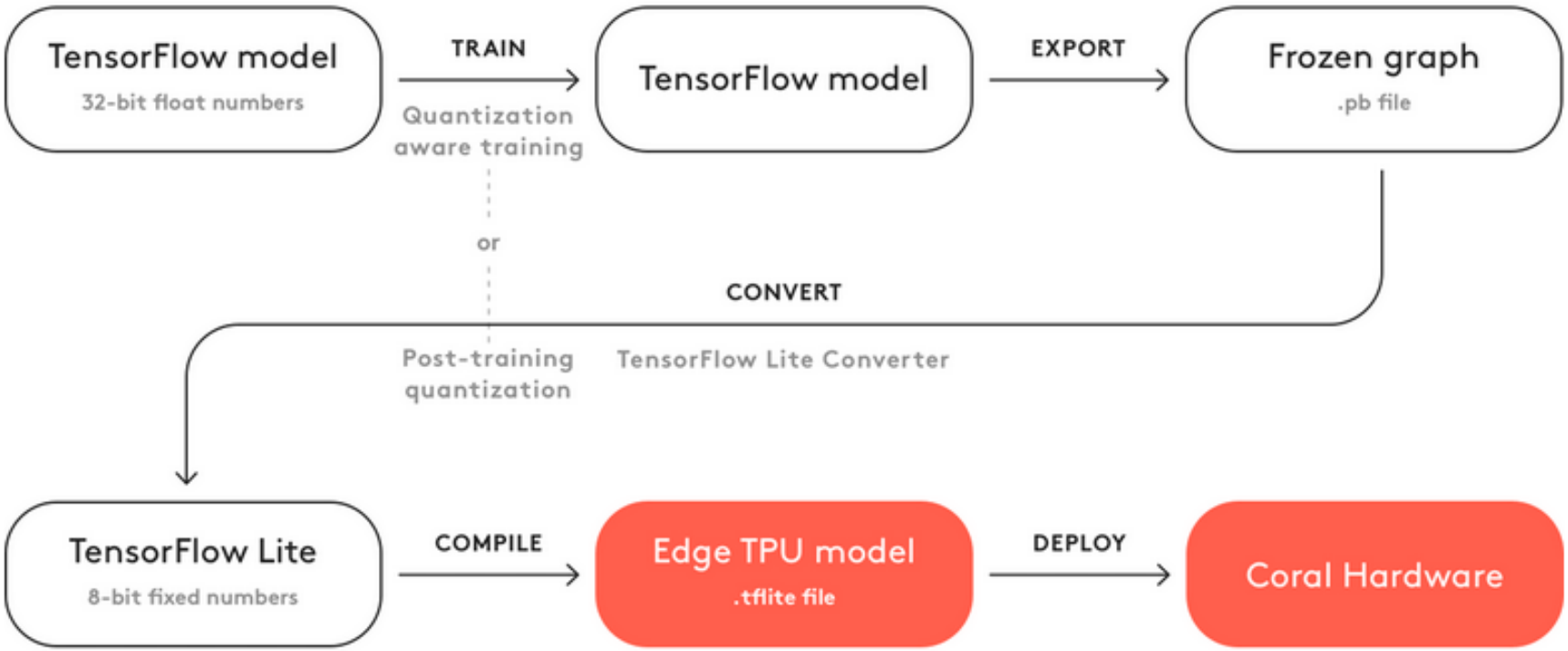
CNN for Cifar-100 classification on Coral Edge TPU

Introduction

Coral USB Accelerator is a device aimed to support a calculator with an operating system.

CNN for Cifar-100 classification on Coral Edge TPU

Requirement, Structure



CNN for Cifar-100 classification on Coral Edge TPU

Requirement, Structure

```
def cnn_model_fn(features, labels, mode):
    with tf.name_scope('model_input') as scope:
    input_layer = tf.reshape(features, [-1, 32, 32, 3], name
    ="input")

    with tf.name_scope('model_conv1') as scope:
    conv1 = tf.layers.conv2d(inputs=input_layer, filters=32,
     kernel_size=[2, 2],
    padding="same", activation=tf.nn.relu6,
    trainable=mode == tf.estimator.ModeKeys.TRAIN)

    with tf.name_scope('model_conv2') as scope:
    conv2 = tf.layers.conv2d(inputs=conv1, filters=32,
    kernel_size=[2, 2],
    padding="same", activation=tf.nn.relu6,
    trainable=mode == tf.estimator.ModeKeys.TRAIN)

    pool1 = tf.layers.max_pooling2d(inputs=conv2, pool_size
    =[2, 2], strides=(2, 2))
    drop1 = tf.layers.dropout(inputs=pool1, rate=0.2)
```

CNN for Cifar-100 classification on Coral Edge TPU

Requirement, Structure

```
with tf.name_scope('model_conv3') as scope:
conv3 = tf.layers.conv2d(inputs=drop1, filters=64,
kernel_size=[2, 2],
padding="same", activation=tf.nn.relu6,
trainable=mode == tf.estimator.ModeKeys.TRAIN)

with tf.name_scope('model_conv4') as scope:
conv4 = tf.layers.conv2d(inputs=conv3, filters=64,
kernel_size=[2, 2],
padding="same", activation=tf.nn.relu6,
trainable=mode == tf.estimator.ModeKeys.TRAIN)
pool2 = tf.layers.max_pooling2d(inputs=conv4, pool_size
=[2, 2], strides=(2, 2))
drop2 = tf.layers.dropout(inputs=pool2, rate=0.3)
```

CNN for Cifar-100 classification on Coral Edge TPU

Tensorflow network definition

```
with tf.name_scope('model_conv5') as scope:
conv5 = tf.layers.conv2d(inputs=drop2, filters=128,
kernel_size=[2, 2],
padding="same", activation=tf.nn.relu6,
trainable=mode == tf.estimator.ModeKeys.TRAIN)

with tf.name_scope('model_conv6') as scope:
conv6 = tf.layers.conv2d(inputs=conv5, filters=128,
kernel_size=[2, 2],
padding="same", activation=tf.nn.relu6,
trainable=mode == tf.estimator.ModeKeys.TRAIN)
pool3 = tf.layers.max_pooling2d(inputs=conv6, pool_size
=[2, 2], strides=(2, 2))
drop3 = tf.layers.dropout(inputs=pool3, rate=0.4)
```

CNN for Cifar-100 classification on Coral Edge TPU

Tensorflow network definition

```
    with tf.name_scope('model_dense') as scope:
    flat = tf.reshape(drop3, [-1, 4 * 4 * 128])

    dense = tf.layers.dense(inputs=flat, units=1024,
    activation=tf.nn.relu6,
    trainable=mode == tf.estimator.ModeKeys.TRAIN)

    drop4 = tf.layers.dropout(inputs=dense, rate=0.5,
   training=mode == tf.estimator.ModeKeys.TRAIN)

    with tf.name_scope('model_output') as scope:
    logits = tf.layers.dense(inputs=drop4, units=10,
   trainable=mode == tf.estimator.ModeKeys.TRAIN)

    predictions = {latin1
    "classes": tf.argmax(inputlatin1=logits, axis=1),
    "probabilities": tf.nn.soflatin1tmax(logits, name="
   softmax_tensor")
}
```

CNN for Cifar-100 classification on Coral Edge TPU

Tensorflow network definition

```
    # TRAIN mode
    if mode == tf.estimator.ModeKeys.TRAIN:
    g = tf.get_default_graph()
    tf.contrib.quantize.create_training_graph(input_graph=g,
     quant_delay=6000)
    optimizer = tf.train.AdamOptimizer(learning_rate=0.001)
    train_op = optimizer.minimize(
    loss=loss,
    global_step=tf.train.get_global_step())
    return tf.estimator.EstimatorSpec(mode=mode, loss=loss,
   train_op=train_op)

    # EVAL mode
    g = tf.get_default_graph()
    tf.contrib.quantize.create_eval_graph(input_graph=g)
    labels = tf.argmax(labels, axis=1)
    eval_metric_ops = {
    "accuracy": tf.metrics.accuracy(labels=labels,
   predictions=predictions["classes"])
}
return tf.estimator.EstimatorSpec(
mode=mode, loss=loss, eval_metric_ops=eval_metric_ops)
```

CNN for Cifar-100 classification on Coral Edge TPU

Training and saving

Training:

```
def fit_all_batches(xEpochs):
    # Train the model
    train_input_fn = tf.estimator.inputs.numpy_input_fn(
    x=train_features,
    y=train_labels,
    batch_size=32,
    num_epochs=xEpochs,
    shuffle=False)

    # train one step and display the probabilties
    cifar10_classifier.train(
    input_fn=train_input_fn,
    steps=None,
    hooks=[logging_hook])
^^I
fit_all_batches(100)
```

Saving in .pb format:

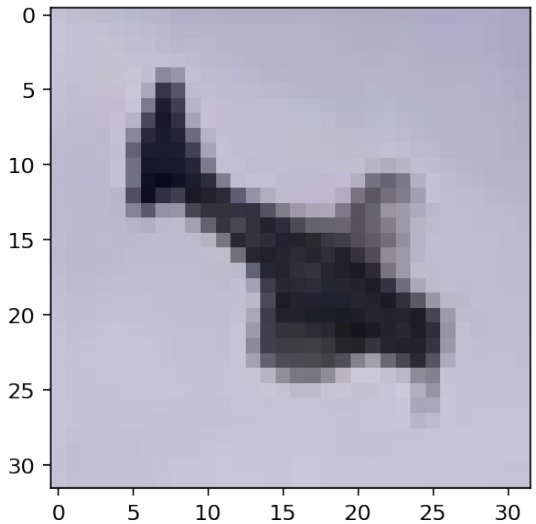
```
cifar10_classifier.experimental_export_all_saved_models(
savedir,
input_receiver_fn_map)
```

CNN for Cifar-100 classification on Coral Edge TPU

Accuracy and test

```
{'accuracy': 0.7656, 'loss': 1.5887853, 'global_step': 142032}
```

```
[['airplane' '0.9999999']
['automobile' '1.5820127e-23']
['bird' '6.063283e-08']
['cat' '7.3694817e-10']
['deer' '2.7018123e-08']
['dog' '1.1388865e-14']
['frog' '5.9821274e-15']
['horse' '1.180477e-18']
['ship' '8.983325e-14']
['truck' '2.4614857e-21']]
```



CNN for Cifar-100 classification on Coral Edge TPU

Frozen graph creation

script Python `freeze_graph.py`

```
tf.saved_model.loader.load(sess,["serve"],savedir )

from tensorflow.python.tools import freeze_graph
from tensorflow.python.saved_model import tag_constants

input_graph_filename = None
input_saved_model_dir = savedir
output_node_names = "softmax_tensor"
output_graph_filename = os.path.join(savedir,"frozen.pb")
input_binary = False
input_saver_def_path = False
restore_op_name = None
filename_tensor_name = None
clear_devices = True
input_meta_graph = False
checkpoint_path = None
```

CNN for Cifar-100 classification on Coral Edge TPU

TFlite conversion

TOCO converter, disponibile con Tensorflow

```
toco \
--input_file=frozen.pb \
--output_file=tflite_model.tflite \
--input_format=TENSORFLOW_GRAPHDEF \
--output_format=TFLITE \
--inference_type=QUANTIZED_UINT8 \
--input_shape="1,32,32,3" \
--input_array=model_input/numberstyleinput \
--output_array=softmax_tensor \
--std_dev_values=127 \
--mean_value=127 \
--default_ranges_min=0 \
--default_ranges_max=6
```

CNN for Cifar-100 classification on Coral Edge TPU

Compilation

Edge TPU Compiler

→ conversione da TF Lite a in un modello per Coral USB Accelerator

```
edgetpu_compiler [options] model...
```

CNN for Cifar-100 classification on Coral Edge TPU

Classification

Classificatore: `CIFAR10_Inference_EdgeTPU.py`

```
python3 my_classifier.py --model=/home/matteo/Documents/
    Frozen/Compiled_models/frozen_edgetpu.tflite --image=/
    home/matteo/Downloads/cifar10_images/truck3.png
WARNING:root:From my_classifier.py:30: The name
    ClassifyWithImage will be deprecated. Please use
    classify_with_image instead.

---------------------------
truck
Score :  0.99609375
Elapsed time for the last inference:  0.03292989730834961
```

CNN for Cifar-100 classification on Coral Edge TPU

Classification

```
python3 my_classifier.py --model=/home/matteo/Documents/
    Frozen/Compiled_models/frozen_example_min_max_edgetpu.
    tflite --image=/home/matteo/Downloads/cifar10_images/
    bird3.png
WARNING:root:From my_classifier.py:30: The name
    ClassifyWithImage will be deprecated. Please use
    classify_with_image instead.

---------------------------
truck
Score :  0.62890625
---------------------------
frog
Score :  0.2890625
Elapsed time for the last inference:  0.03208661079406738
```