TP2_MLIP

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[1]:
```
%load_ext autoreload
%autoreload 2

%matplotlib inline
```

0.0.1 Curso-Taller 2019: Aprendizaje Automático e Imágenes en Python

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[2]:
```
import numpy as np
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
import keras

from PIL import Image
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
from keras.layers import Input, Dense, Conv2D, MaxPooling2D, Flatten,␣
↪BatchNormalization, Activation, Dropout
from keras.models import Model, Sequential
from keras.callbacks import EarlyStopping, ModelCheckpoint, Callback
from keras.optimizers import RMSprop
from keras.preprocessing.image import ImageDataGenerator
from tensorflow.examples.tutorials.mnist import input_data

from IPython.display import Image as IPImage

import warnings
warnings.filterwarnings("ignore")
```

```
Using TensorFlow backend.
```

[3]:
```
print(tf.__version__)
print(keras.__version__)
```

```
1.15.0
2.2.5
```

[4]:
```
sns.set_style("white")
```

Ejercicio 1

Cargamos los datos del MNIST

[5]:
```
# importo y guardo MNIST data
mnist = input_data.read_data_sets("./mnist/data/", one_hot=True)
```

```
WARNING:tensorflow:From <ipython-input-5-5933df94991b>:2: read_data_sets (from
tensorflow.contrib.learn.python.learn.datasets.mnist) is deprecated and will be
removed in a future version.
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from
tensorflow/models.
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/tensorflow_core/contrib/learn/python/learn/datasets/mnist.py:260:
maybe_download (from tensorflow.contrib.learn.python.learn.datasets.base) is
deprecated and will be removed in a future version.
Instructions for updating:
Please write your own downloading logic.
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/tensorflow_core/contrib/learn/python/learn/datasets/mnist.py:262:
extract_images (from tensorflow.contrib.learn.python.learn.datasets.mnist) is
deprecated and will be removed in a future version.
Instructions for updating:
Please use tf.data to implement this functionality.
Extracting ./mnist/data/train-images-idx3-ubyte.gz
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/tensorflow_core/contrib/learn/python/learn/datasets/mnist.py:267:
extract_labels (from tensorflow.contrib.learn.python.learn.datasets.mnist) is
deprecated and will be removed in a future version.
Instructions for updating:
Please use tf.data to implement this functionality.
Extracting ./mnist/data/train-labels-idx1-ubyte.gz
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/tensorflow_core/contrib/learn/python/learn/datasets/mnist.py:110:
dense_to_one_hot (from tensorflow.contrib.learn.python.learn.datasets.mnist) is
deprecated and will be removed in a future version.
Instructions for updating:
Please use tf.one_hot on tensors.
Extracting ./mnist/data/t10k-images-idx3-ubyte.gz
Extracting ./mnist/data/t10k-labels-idx1-ubyte.gz
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
```

```
packages/tensorflow_core/contrib/learn/python/learn/datasets/mnist.py:290:
DataSet.__init__ (from tensorflow.contrib.learn.python.learn.datasets.mnist) is
deprecated and will be removed in a future version.
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from
tensorflow/models.
```

[6]:
```
X_train = mnist.train.images
y_train = mnist.train.labels

X_val = mnist.validation.images
y_val = mnist.validation.labels

X_test = mnist.test.images
y_test = mnist.test.labels
```

[7]:
```
print(f"X_train shape: {X_train.shape}")
print(f"y_train shape: {y_train.shape}")
print()
print(f"X_val shape  : {X_val.shape}")
print(f"y_val shape  : {y_val.shape}")
print()
print(f"X_test shape : {X_test.shape}")
print(f"y_test shape : {y_test.shape}")
```

```
X_train shape: (55000, 784)
y_train shape: (55000, 10)

X_val shape  : (5000, 784)
y_val shape  : (5000, 10)

X_test shape : (10000, 784)
y_test shape : (10000, 10)
```

Ejercicio2

Defina dos redes totalmente conectadas diferentes que sean capaces de clasificar la base MNIST.

Una con 3 capas ocultas y la otra con 5.

Evalúe posible overfitting en ambas y compárelas usándola parte de entrenamiento y la parte de la base destinada para validación.

[ ]:
```

```

Red Fully Connected - 3 Capas Ocultas

[8]:
```
model_3hl = Sequential()
model_3hl.add(Dense(512, input_shape=(784,), activation="relu"))
model_3hl.add(Dense(1024, activation="relu"))
model_3hl.add(Dense(512, activation="relu"))
model_3hl.add(Dense(10, activation="softmax"))

model_3hl.compile(
    loss='categorical_crossentropy',
    metrics=['accuracy'],
    optimizer='adam'
)
```

```
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:66: The name tf.get_default_graph
is deprecated. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:541: The name tf.placeholder is
deprecated. Please use tf.compat.v1.placeholder instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:4432: The name tf.random_uniform is
deprecated. Please use tf.random.uniform instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/optimizers.py:793: The name tf.train.Optimizer is deprecated.
Please use tf.compat.v1.train.Optimizer instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:3576: The name tf.log is
deprecated. Please use tf.math.log instead.
```

[9]:
```
BATCH_SIZE = 128
NUM_EPOCHS = 20

history_3hl = model_3hl.fit(
    X_train, y_train,
    batch_size=BATCH_SIZE,
    epochs=NUM_EPOCHS,
    verbose=1,
    validation_data=(X_val, y_val)
)
```

```
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/tensorflow_core/python/ops/math_grad.py:1424: where (from
tensorflow.python.ops.array_ops) is deprecated and will be removed in a future
version.
```

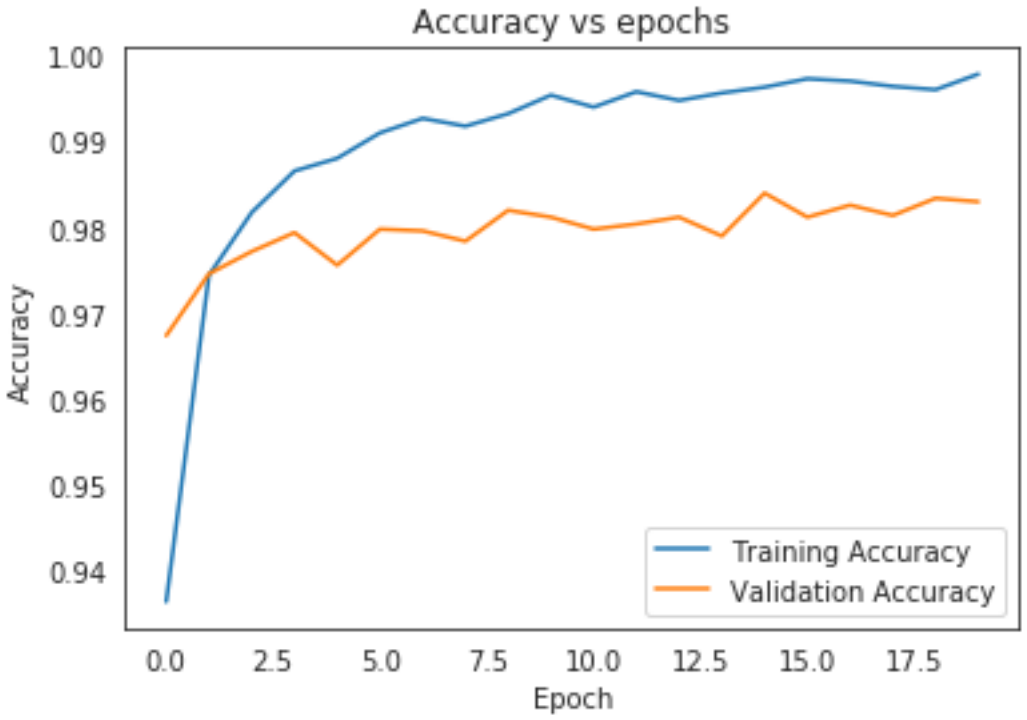
```
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:1033: The name tf.assign_add is
deprecated. Please use tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:1020: The name tf.assign is
deprecated. Please use tf.compat.v1.assign instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:3005: The name tf.Session is
deprecated. Please use tf.compat.v1.Session instead.

Train on 55000 samples, validate on 5000 samples
Epoch 1/20
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:190: The name
tf.get_default_session is deprecated. Please use
tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:197: The name tf.ConfigProto is
deprecated. Please use tf.compat.v1.ConfigProto instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:207: The name tf.global_variables
is deprecated. Please use tf.compat.v1.global_variables instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:216: The name
tf.is_variable_initialized is deprecated. Please use
tf.compat.v1.is_variable_initialized instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:223: The name
tf.variables_initializer is deprecated. Please use
tf.compat.v1.variables_initializer instead.

55000/55000 [==============================] - 10s 174us/step - loss: 0.2100 -
acc: 0.9364 - val_loss: 0.1046 - val_acc: 0.9674
Epoch 2/20
55000/55000 [==============================] - 9s 164us/step - loss: 0.0827 -
acc: 0.9744 - val_loss: 0.0787 - val_acc: 0.9746
Epoch 3/20
55000/55000 [==============================] - 9s 163us/step - loss: 0.0573 -
acc: 0.9817 - val_loss: 0.0759 - val_acc: 0.9772
Epoch 4/20
```

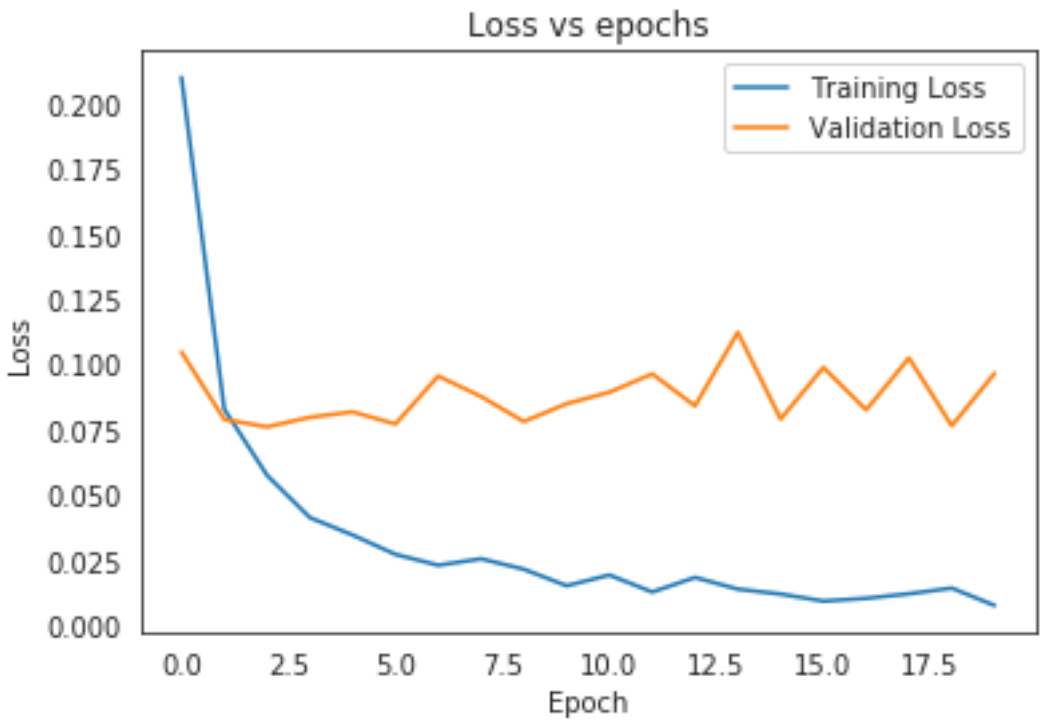
```
55000/55000 [==============================] - 9s 164us/step - loss: 0.0411 -
acc: 0.9866 - val_loss: 0.0795 - val_acc: 0.9794
Epoch 5/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0344 -
acc: 0.9881 - val_loss: 0.0816 - val_acc: 0.9756
Epoch 6/20
55000/55000 [==============================] - 9s 164us/step - loss: 0.0270 -
acc: 0.9910 - val_loss: 0.0770 - val_acc: 0.9798
Epoch 7/20
55000/55000 [==============================] - 9s 167us/step - loss: 0.0228 -
acc: 0.9927 - val_loss: 0.0954 - val_acc: 0.9796
Epoch 8/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0253 -
acc: 0.9918 - val_loss: 0.0875 - val_acc: 0.9784
Epoch 9/20
55000/55000 [==============================] - 9s 164us/step - loss: 0.0213 -
acc: 0.9933 - val_loss: 0.0779 - val_acc: 0.9820
Epoch 10/20
55000/55000 [==============================] - 9s 164us/step - loss: 0.0150 -
acc: 0.9954 - val_loss: 0.0848 - val_acc: 0.9812
Epoch 11/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0191 -
acc: 0.9940 - val_loss: 0.0892 - val_acc: 0.9798
Epoch 12/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0126 -
acc: 0.9958 - val_loss: 0.0962 - val_acc: 0.9804
Epoch 13/20
55000/55000 [==============================] - 9s 166us/step - loss: 0.0181 -
acc: 0.9948 - val_loss: 0.0839 - val_acc: 0.9812
Epoch 14/20
55000/55000 [==============================] - 9s 166us/step - loss: 0.0137 -
acc: 0.9957 - val_loss: 0.1121 - val_acc: 0.9790
Epoch 15/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0118 -
acc: 0.9963 - val_loss: 0.0789 - val_acc: 0.9840
Epoch 16/20
55000/55000 [==============================] - 9s 165us/step - loss: 0.0091 -
acc: 0.9973 - val_loss: 0.0987 - val_acc: 0.9812
Epoch 17/20
55000/55000 [==============================] - 9s 167us/step - loss: 0.0101 -
acc: 0.9971 - val_loss: 0.0824 - val_acc: 0.9826
Epoch 18/20
55000/55000 [==============================] - 9s 166us/step - loss: 0.0119 -
acc: 0.9964 - val_loss: 0.1023 - val_acc: 0.9814
Epoch 19/20
55000/55000 [==============================] - 9s 166us/step - loss: 0.0141 -
acc: 0.9961 - val_loss: 0.0763 - val_acc: 0.9834
Epoch 20/20
```

```
55000/55000 [==============================] - 9s 168us/step - loss: 0.0074 -
acc: 0.9979 - val_loss: 0.0964 - val_acc: 0.9830
```

[10]:
```
## Visualizamos curvas de entrenamiento

plt.figure()
plt.title("Accuracy vs epochs")
plt.plot(history_3hl.history['acc'])
plt.plot(history_3hl.history['val_acc'])
plt.legend(['Training Accuracy', 'Validation Accuracy'])
plt.xlabel("Epoch")
plt.ylabel("Accuracy")


plt.figure()
plt.title("Loss vs epochs")
plt.plot(history_3hl.history['loss'])
plt.plot(history_3hl.history['val_loss'])
plt.legend(['Training Loss', 'Validation Loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss")
```

[10]:
```
Text(0,0.5,'Loss')
```





[ ]:

Red Fully Connected - 5 Capas Ocultas

[11]:
```
model_5hl = Sequential()
model_5hl.add(Dense(512, input_shape=(784,), activation="relu"))
model_5hl.add(Dense(1024, activation="relu"))
model_5hl.add(Dense(1024, activation="relu"))
model_5hl.add(Dense(1024, activation="relu"))
model_5hl.add(Dense(512, activation="relu"))
model_5hl.add(Dense(10, activation="softmax"))

model_5hl.compile(
    loss='categorical_crossentropy',
    metrics=['accuracy'],
    optimizer='adam'
)
```

[12]:
```
BATCH_SIZE = 128
NUM_EPOCHS = 20

history_5hl = model_5hl.fit(
    X_train, y_train,
    batch_size=BATCH_SIZE,
```

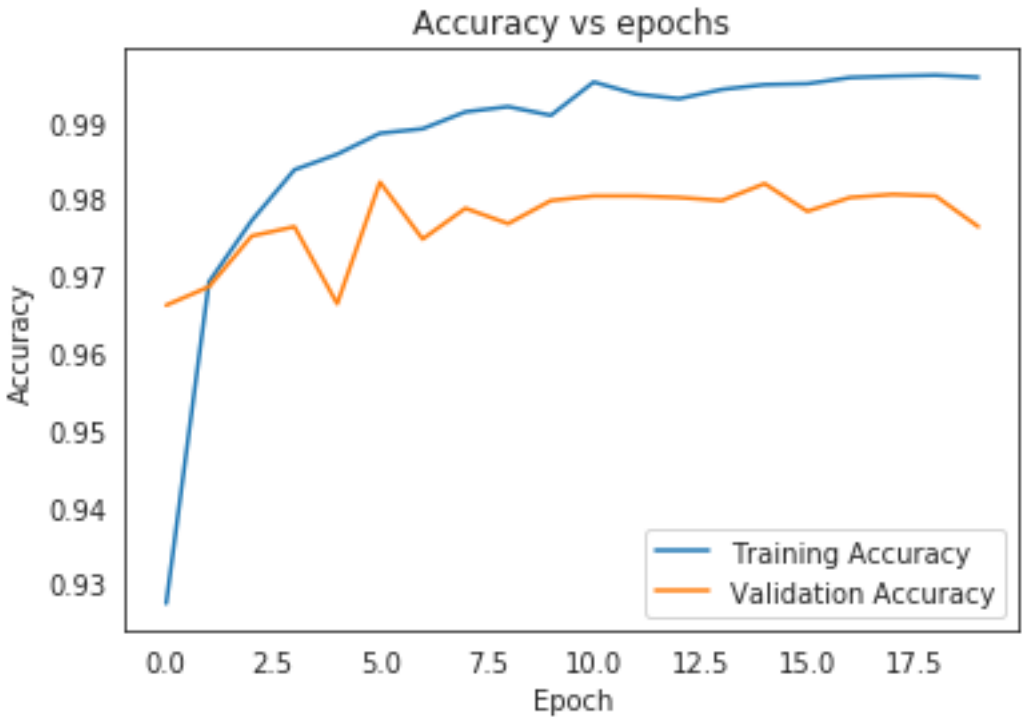
```
    epochs=NUM_EPOCHS,
    verbose=1,
    validation_data=(X_val, y_val)
)
```

```
Train on 55000 samples, validate on 5000 samples
Epoch 1/20
55000/55000 [==============================] - 23s 412us/step - loss: 0.2396 -
acc: 0.9275 - val_loss: 0.1137 - val_acc: 0.9662
Epoch 2/20
55000/55000 [==============================] - 22s 397us/step - loss: 0.1053 -
acc: 0.9692 - val_loss: 0.1000 - val_acc: 0.9686
Epoch 3/20
55000/55000 [==============================] - 22s 403us/step - loss: 0.0765 -
acc: 0.9772 - val_loss: 0.0919 - val_acc: 0.9752
Epoch 4/20
55000/55000 [==============================] - 22s 399us/step - loss: 0.0528 -
acc: 0.9838 - val_loss: 0.0956 - val_acc: 0.9764
Epoch 5/20
55000/55000 [==============================] - 22s 399us/step - loss: 0.0497 -
acc: 0.9858 - val_loss: 0.1267 - val_acc: 0.9664
Epoch 6/20
55000/55000 [==============================] - 22s 401us/step - loss: 0.0396 -
acc: 0.9885 - val_loss: 0.0741 - val_acc: 0.9822
Epoch 7/20
55000/55000 [==============================] - 22s 403us/step - loss: 0.0406 -
acc: 0.9891 - val_loss: 0.1016 - val_acc: 0.9748
Epoch 8/20
55000/55000 [==============================] - 22s 400us/step - loss: 0.0312 -
acc: 0.9913 - val_loss: 0.0946 - val_acc: 0.9788
Epoch 9/20
55000/55000 [==============================] - 22s 400us/step - loss: 0.0278 -
acc: 0.9920 - val_loss: 0.1148 - val_acc: 0.9768
Epoch 10/20
55000/55000 [==============================] - 22s 395us/step - loss: 0.0338 -
acc: 0.9909 - val_loss: 0.0974 - val_acc: 0.9798
Epoch 11/20
55000/55000 [==============================] - 22s 395us/step - loss: 0.0183 -
acc: 0.9952 - val_loss: 0.0880 - val_acc: 0.9804
Epoch 12/20
55000/55000 [==============================] - 22s 397us/step - loss: 0.0249 -
acc: 0.9936 - val_loss: 0.0967 - val_acc: 0.9804
Epoch 13/20
55000/55000 [==============================] - 22s 401us/step - loss: 0.0257 -
acc: 0.9930 - val_loss: 0.0989 - val_acc: 0.9802
Epoch 14/20
55000/55000 [==============================] - 22s 401us/step - loss: 0.0224 -
```

```
acc: 0.9942 - val_loss: 0.1058 - val_acc: 0.9798
Epoch 15/20
55000/55000 [==============================] - 22s 395us/step - loss: 0.0215 -
acc: 0.9949 - val_loss: 0.0993 - val_acc: 0.9820
Epoch 16/20
55000/55000 [==============================] - 22s 392us/step - loss: 0.0195 -
acc: 0.9950 - val_loss: 0.1253 - val_acc: 0.9784
Epoch 17/20
55000/55000 [==============================] - 22s 394us/step - loss: 0.0167 -
acc: 0.9958 - val_loss: 0.1127 - val_acc: 0.9802
Epoch 18/20
55000/55000 [==============================] - 22s 392us/step - loss: 0.0165 -
acc: 0.9960 - val_loss: 0.1147 - val_acc: 0.9806
Epoch 19/20
55000/55000 [==============================] - 22s 392us/step - loss: 0.0159 -
acc: 0.9961 - val_loss: 0.1269 - val_acc: 0.9804
Epoch 20/20
55000/55000 [==============================] - 22s 409us/step - loss: 0.0190 -
acc: 0.9958 - val_loss: 0.1492 - val_acc: 0.9764
```

[13]:
```
## Visualizamos curvas de entrenamiento

plt.figure()
plt.title("Accuracy vs epochs")
plt.plot(history_5hl.history['acc'])
plt.plot(history_5hl.history['val_acc'])
plt.legend(['Training Accuracy', 'Validation Accuracy'])
plt.xlabel("Epoch")
plt.ylabel("Accuracy")


plt.figure()
plt.title("Loss vs epochs")
plt.plot(history_5hl.history['loss'])
plt.plot(history_5hl.history['val_loss'])
plt.legend(['Training Loss', 'Validation Loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss")
```

[13]:
```
Text(0,0.5,'Loss')
```


Accuracy vs epochs
Accuracy
0.99
0.98
0.97
0.96
0.95
0.94
0.93
Training Accuracy
Validation Accuracy
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Epoch


Loss vs epochs
Loss
0.25
0.20
0.15
0.10
0.05
Training Loss
Validation Loss
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Epoch

Conclusión: Las dos redes overfittean, pero la que menos overfitting presenta es la red con 3 capas ocultas.

Ejercicio 3

Use la comparación anterior para elegir un modelo.

Realice las predicciones en el conjunto de test y grafique 9 imágenes mal clasificada por el modelo elegido.

[14]:
```
score_3hl = model_3hl.evaluate(X_test, y_test, verbose=1)
print(f'Test Loss    : {score_3hl[0]}')
print(f'Test Accuracy: {score_3hl[1]}')
```

```
10000/10000 [==============================] - 1s 67us/step
Test Loss    : 0.1029824515523373
Test Accuracy: 0.9811
```

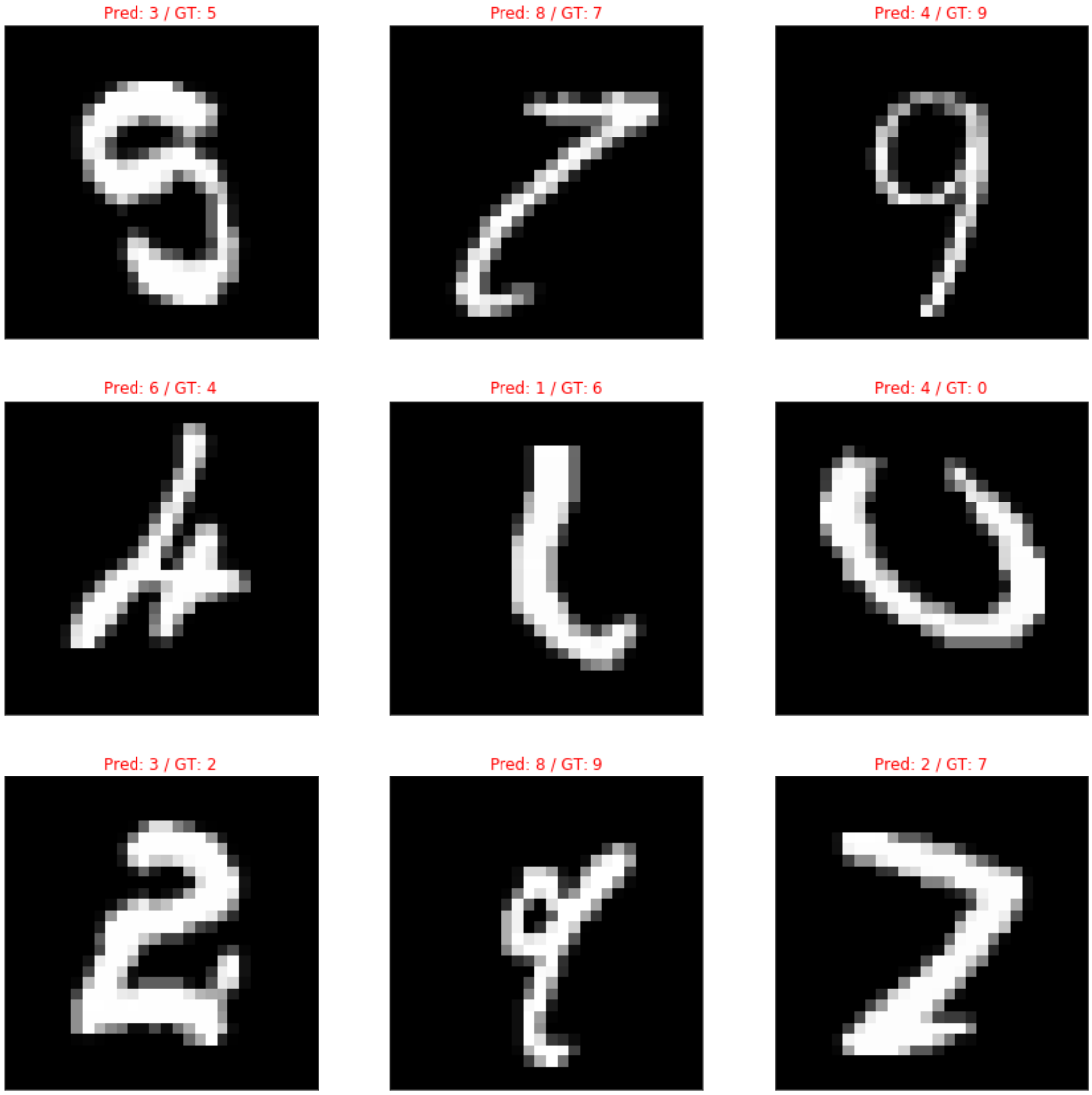
[15]:
```
y_pred = model_3hl.predict_classes(X_test)

display(y_test)
display(y_pred)
```

```
array([[0., 0., 0., ..., 1., 0., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.]])


array([7, 2, 1, ..., 4, 5, 6])
```

[16]:
```
enc = OneHotEncoder()
y_pred_onehot = enc.fit_transform(y_pred.reshape(-1, 1)).toarray()

display(y_pred_onehot)
```

```
array([[0., 0., 0., ..., 1., 0., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.]])
```

[17]:
```
idxs_wrong_pred = np.array([i for i in range(len(y_test)) if (y_pred_onehot[i] !
 ↪= y_test[i]).any()])

# Visualizamos algunas imagenes
fig, ax = plt.subplots(3, 3, figsize=[15, 15])

for j in range(3):
    for i in range(3):
        for idx in np.random.choice(idxs_wrong_pred, 9):
            image = X_test[idx]
            ground_truth = int(enc.inverse_transform(y_test[idx].reshape(1,␣
 ↪-1))[0][0])
            pred = int(enc.inverse_transform(y_pred_onehot[idx].reshape(1,␣
 ↪-1))[0][0])

            ax[i,j].imshow(image.reshape(28, 28), 'gray')
            ax[i,j].set_title(f'Pred: {pred} / GT: {ground_truth}', color='r')
            ax[i,j].set_xticks([])
            ax[i,j].set_yticks([])

# fig.subplots_adjust(wspace=0.1, hspace=0)
# plt.title("9 imágenes mal clasificada en el conjunto de test")
plt.show()
```



Ejercicio 4

Defina dos redes convolucionales diferentes que sean capaces de clasificar la base MNIST.

Utilice para entrenar ambas la base de entrenamiento aumentada (por 21=3x3x3) utilizando rotación, escala y traslación.

[18]:
```
X_train = mnist.train.images
y_train = mnist.train.labels

X_val = mnist.validation.images
y_val = mnist.validation.labels
```

```
X_test = mnist.test.images
y_test = mnist.test.labels
```

[19]:
```
X_train = X_train.reshape(55000, 28, 28, 1)
X_val = X_val.reshape(5000, 28, 28, 1)
X_test = X_test.reshape(10000, 28, 28, 1)
```

[20]:
```
print(f"X_train shape: {X_train.shape}")
print(f"y_train shape: {y_train.shape}")
print()
print(f"X_val shape  : {X_val.shape}")
print(f"y_val shape  : {y_val.shape}")
print()
print(f"X_test shape : {X_test.shape}")
print(f"y_test shape : {y_test.shape}")
```

```
X_train shape: (55000, 28, 28, 1)
y_train shape: (55000, 10)

X_val shape  : (5000, 28, 28, 1)
y_val shape  : (5000, 10)

X_test shape : (10000, 28, 28, 1)
y_test shape : (10000, 10)
```

[21]:
```
##### Some Constants #####
IMG_ROWS = 28
IMG_COLS = 28
NUM_CLASSES = 10

BATCH_SIZE = 128
NUM_EPOCHS = 20
```

[22]:
```
### Data Augmentation ###

# Training data generator
datagen_train = ImageDataGenerator(
    # rescale=1./255,  # We also can make a rescale on the data
    rotation_range=10,
    width_shift_range=0.2,
    height_shift_range=0.2
)

# Validation data generator
datagen_val = ImageDataGenerator(
    # rescale=1./255,  # We also can make a rescale on the data
)
```

```
########################
```

CNN sin dropout

[23]:
```
inputs = Input(shape=(IMG_ROWS, IMG_COLS, 1))

conv1 = Conv2D(64, 5, activation="relu")(inputs)
maxPool1 = MaxPooling2D(pool_size=(2, 2))(conv1)

conv2 = Conv2D(128, 3, activation="relu")(maxPool1)
maxPool2 = MaxPooling2D(pool_size=(2, 2))(conv2)

flatten = Flatten()(maxPool2)

dense1 = Dense(256, activation="sigmoid")(flatten)
dense2 = Dense(64, activation="sigmoid")(dense1)

outputs = Dense(NUM_CLASSES, activation="softmax")(dense2)

model_cnn1 = Model(
    inputs=inputs,
    outputs=outputs
)

model_cnn1.compile(
    optimizer='adam',
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
```

```
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:4267: The name tf.nn.max_pool is
deprecated. Please use tf.nn.max_pool2d instead.
```

[24]:
```
model_cnn1.summary()
```

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 28, 28, 1)         0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 24, 24, 64)        1664
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
```

```
conv2d_2 (Conv2D)            (None, 10, 10, 128)       73856
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 5, 5, 128)         0
_________________________________________________________________
flatten_1 (Flatten)          (None, 3200)              0
_________________________________________________________________
dense_11 (Dense)             (None, 256)               819456
_________________________________________________________________
dense_12 (Dense)             (None, 64)                16448
_________________________________________________________________
dense_13 (Dense)             (None, 10)                650
=================================================================
Total params: 912,074
Trainable params: 912,074
Non-trainable params: 0
_________________________________________________________________
```

[25]:
```
history_cnn1 = model_cnn1.fit_generator(
    datagen_train.flow(X_train, y_train, batch_size=BATCH_SIZE),
    steps_per_epoch=X_train.shape[0] // BATCH_SIZE,
    epochs=NUM_EPOCHS,
    verbose=1,
    validation_data=datagen_val.flow(X_val, y_val, batch_size=BATCH_SIZE),
    validation_steps=X_val.shape[0] // BATCH_SIZE
)
```

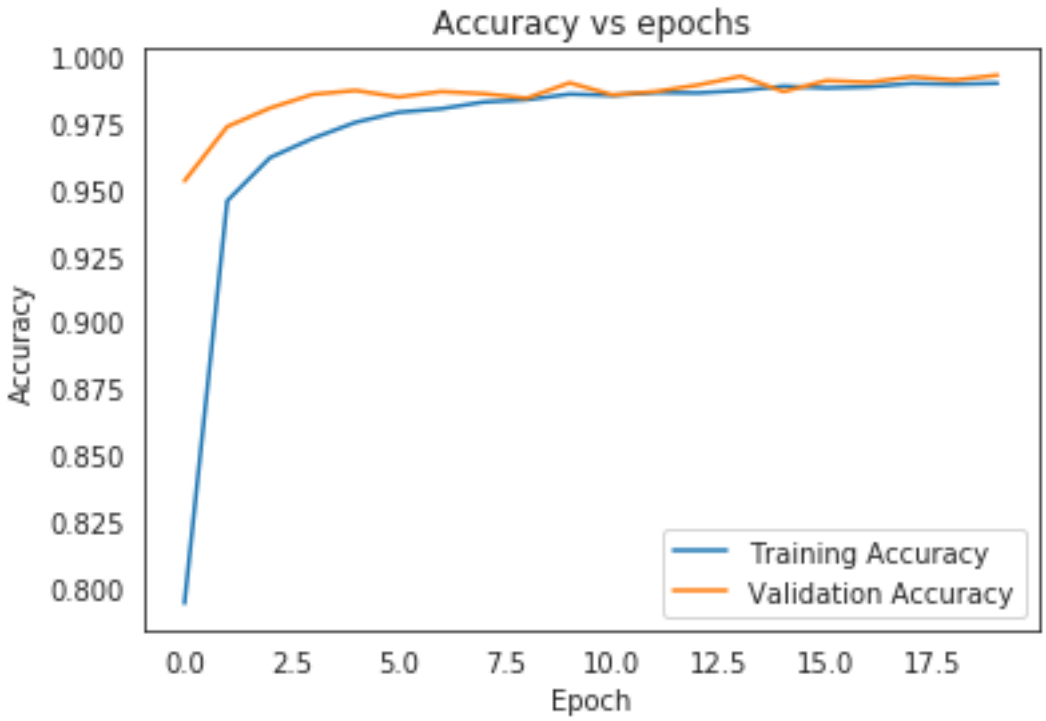
```
Epoch 1/20
429/429 [==============================] - 52s 122ms/step - loss: 0.7443 - acc:
0.7946 - val_loss: 0.1806 - val_acc: 0.9529
Epoch 2/20
429/429 [==============================] - 52s 121ms/step - loss: 0.1993 - acc:
0.9455 - val_loss: 0.0984 - val_acc: 0.9733
Epoch 3/20
429/429 [==============================] - 52s 121ms/step - loss: 0.1323 - acc:
0.9617 - val_loss: 0.0674 - val_acc: 0.9803
Epoch 4/20
429/429 [==============================] - 52s 120ms/step - loss: 0.1043 - acc:
0.9689 - val_loss: 0.0541 - val_acc: 0.9854
Epoch 5/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0828 - acc:
0.9750 - val_loss: 0.0444 - val_acc: 0.9869
Epoch 6/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0711 - acc:
0.9787 - val_loss: 0.0542 - val_acc: 0.9844
Epoch 7/20
429/429 [==============================] - 52s 120ms/step - loss: 0.0651 - acc:
0.9800 - val_loss: 0.0420 - val_acc: 0.9865
Epoch 8/20
```

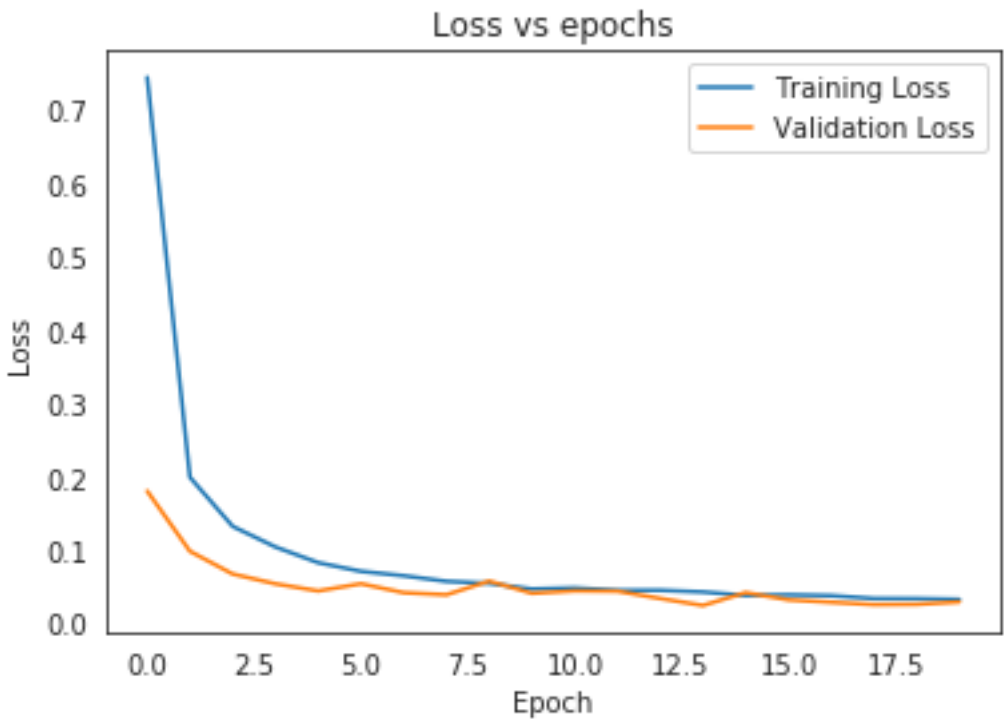
```
429/429 [==============================] - 51s 120ms/step - loss: 0.0574 - acc:
0.9826 - val_loss: 0.0391 - val_acc: 0.9856
Epoch 9/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0547 - acc:
0.9834 - val_loss: 0.0578 - val_acc: 0.9840
Epoch 10/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0470 - acc:
0.9855 - val_loss: 0.0412 - val_acc: 0.9897
Epoch 11/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0484 - acc:
0.9850 - val_loss: 0.0445 - val_acc: 0.9852
Epoch 12/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0452 - acc:
0.9861 - val_loss: 0.0440 - val_acc: 0.9865
Epoch 13/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0453 - acc:
0.9859 - val_loss: 0.0341 - val_acc: 0.9889
Epoch 14/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0430 - acc:
0.9869 - val_loss: 0.0245 - val_acc: 0.9922
Epoch 15/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0383 - acc:
0.9885 - val_loss: 0.0421 - val_acc: 0.9865
Epoch 16/20
429/429 [==============================] - 51s 120ms/step - loss: 0.0390 - acc:
0.9878 - val_loss: 0.0323 - val_acc: 0.9906
Epoch 17/20
429/429 [==============================] - 52s 120ms/step - loss: 0.0380 - acc:
0.9882 - val_loss: 0.0289 - val_acc: 0.9899
Epoch 18/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0340 - acc:
0.9895 - val_loss: 0.0257 - val_acc: 0.9920
Epoch 19/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0338 - acc:
0.9892 - val_loss: 0.0261 - val_acc: 0.9908
Epoch 20/20
429/429 [==============================] - 52s 121ms/step - loss: 0.0329 - acc:
0.9896 - val_loss: 0.0294 - val_acc: 0.9926
```

[26]:
```
## Visualizamos curvas de entrenamiento

plt.figure()
plt.title("Accuracy vs epochs")
plt.plot(history_cnn1.history['acc'])
plt.plot(history_cnn1.history['val_acc'])
plt.legend(['Training Accuracy', 'Validation Accuracy'])
plt.xlabel("Epoch")
```

```
plt.ylabel("Accuracy")


plt.figure()
plt.title("Loss vs epochs")
plt.plot(history_cnn1.history['loss'])
plt.plot(history_cnn1.history['val_loss'])
plt.legend(['Training Loss', 'Validation Loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss")
```

[26]: Text(0,0.5,'Loss')





[30]:
```
score_cnn1 = model_cnn1.evaluate(X_test, y_test, verbose=1)
print(f'Test Loss     : {score_cnn1[0]}')
print(f'Test Accuracy: {score_cnn1[1]}')
```

```
10000/10000 [==============================] - 3s 266us/step
Test Loss     : 0.028125276191858575
Test Accuracy: 0.9915
```

[ ]:
```

```

CNN con dropout

[27]:
```
inputs = Input(shape=(IMG_ROWS, IMG_COLS, 1))

conv1 = Conv2D(64, 5, activation=None)(inputs)
bn1 = BatchNormalization()(conv1)
activation1 = Activation("relu")(bn1)
maxPool1 = MaxPooling2D(pool_size=(2, 2))(activation1)

conv2 = Conv2D(128, 5, activation=None)(maxPool1)
bn2 = BatchNormalization()(conv2)
activation2 = Activation("relu")(bn2)
maxPool2 = MaxPooling2D(pool_size=(2, 2))(activation2)
```

```
flatten = Flatten()(maxPool2)

dense1 = Dense(256, activation="sigmoid")(flatten)
dense1 = Dropout(0.5)(dense1)

dense2 = Dense(64, activation="sigmoid")(dense1)
dense2 = Dropout(0.5)(dense2)

outputs = Dense(NUM_CLASSES, activation="softmax")(dense2)

model_cnn2 = Model(
    inputs=inputs,
    outputs=outputs
)

model_cnn2.compile(
    optimizer='adam',
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
```

```
WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:2041: The name
tf.nn.fused_batch_norm is deprecated. Please use
tf.compat.v1.nn.fused_batch_norm instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:148: The name
tf.placeholder_with_default is deprecated. Please use
tf.compat.v1.placeholder_with_default instead.

WARNING:tensorflow:From /home/ubuntu/miniconda3/envs/mlip/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:3733: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed
in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 -
keep_prob`.
```

[28]:
```
history_cnn2 = model_cnn2.fit_generator(
    datagen_train.flow(X_train, y_train, batch_size=BATCH_SIZE),
    steps_per_epoch=X_train.shape[0] // BATCH_SIZE,
    epochs=NUM_EPOCHS,
    validation_data=datagen_val.flow(X_val, y_val, batch_size=BATCH_SIZE),
    validation_steps=X_val.shape[0] // BATCH_SIZE
)
```

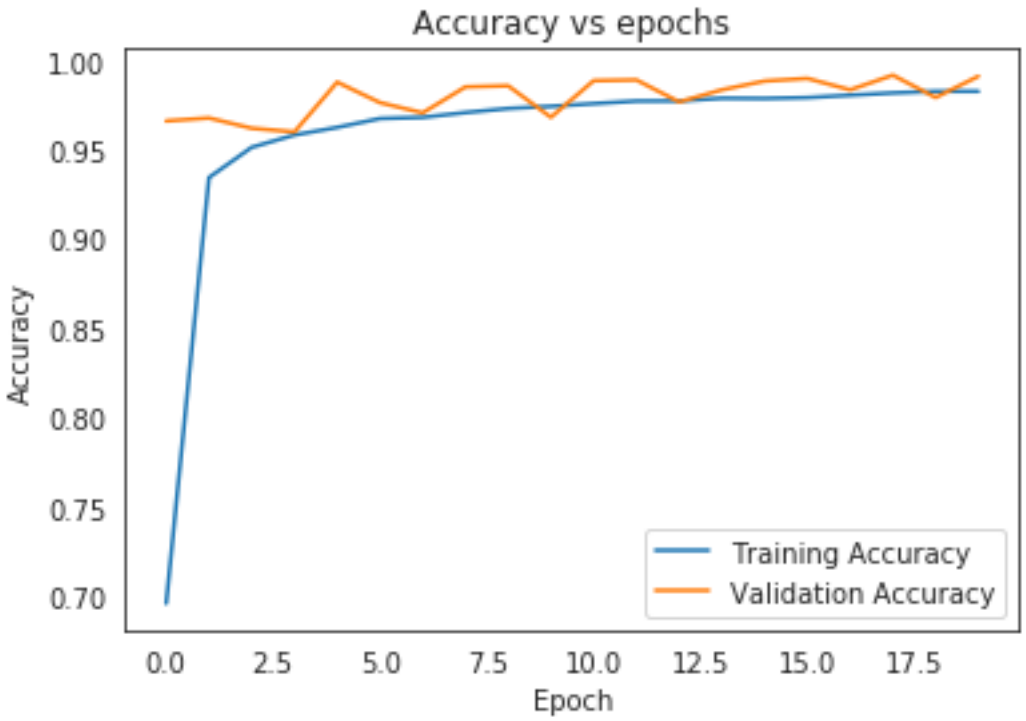
```
Epoch 1/20
```

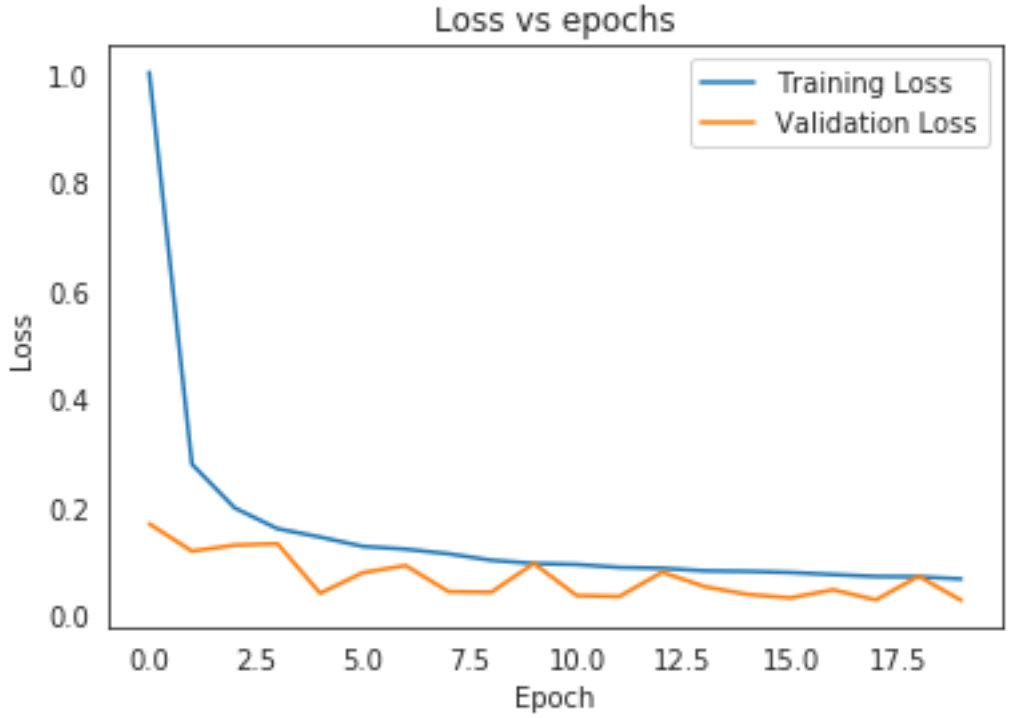
```
429/429 [==============================] - 122s 285ms/step - loss: 1.0040 - acc:
0.6955 - val_loss: 0.1691 - val_acc: 0.9663
Epoch 2/20
429/429 [==============================] - 121s 283ms/step - loss: 0.2789 - acc:
0.9346 - val_loss: 0.1184 - val_acc: 0.9680
Epoch 3/20
429/429 [==============================] - 121s 283ms/step - loss: 0.1983 - acc:
0.9516 - val_loss: 0.1295 - val_acc: 0.9622
Epoch 4/20
429/429 [==============================] - 122s 284ms/step - loss: 0.1598 - acc:
0.9584 - val_loss: 0.1322 - val_acc: 0.9602
Epoch 5/20
429/429 [==============================] - 122s 284ms/step - loss: 0.1443 - acc:
0.9627 - val_loss: 0.0407 - val_acc: 0.9881
Epoch 6/20
429/429 [==============================] - 121s 283ms/step - loss: 0.1271 - acc:
0.9677 - val_loss: 0.0788 - val_acc: 0.9766
Epoch 7/20
429/429 [==============================] - 121s 283ms/step - loss: 0.1221 - acc:
0.9684 - val_loss: 0.0918 - val_acc: 0.9709
Epoch 8/20
429/429 [==============================] - 121s 283ms/step - loss: 0.1135 - acc:
0.9710 - val_loss: 0.0438 - val_acc: 0.9854
Epoch 9/20
429/429 [==============================] - 122s 284ms/step - loss: 0.1016 - acc:
0.9733 - val_loss: 0.0424 - val_acc: 0.9860
Epoch 10/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0956 - acc:
0.9745 - val_loss: 0.0957 - val_acc: 0.9684
Epoch 11/20
429/429 [==============================] - 121s 282ms/step - loss: 0.0938 - acc:
0.9760 - val_loss: 0.0363 - val_acc: 0.9889
Epoch 12/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0883 - acc:
0.9775 - val_loss: 0.0347 - val_acc: 0.9893
Epoch 13/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0867 - acc:
0.9775 - val_loss: 0.0796 - val_acc: 0.9770
Epoch 14/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0820 - acc:
0.9790 - val_loss: 0.0527 - val_acc: 0.9838
Epoch 15/20
429/429 [==============================] - 121s 282ms/step - loss: 0.0811 - acc:
0.9789 - val_loss: 0.0385 - val_acc: 0.9887
Epoch 16/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0790 - acc:
0.9794 - val_loss: 0.0320 - val_acc: 0.9901
Epoch 17/20
```

```
429/429 [==============================] - 121s 283ms/step - loss: 0.0752 - acc:
0.9808 - val_loss: 0.0471 - val_acc: 0.9838
Epoch 18/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0717 - acc:
0.9820 - val_loss: 0.0283 - val_acc: 0.9920
Epoch 19/20
429/429 [==============================] - 122s 283ms/step - loss: 0.0711 - acc:
0.9829 - val_loss: 0.0721 - val_acc: 0.9795
Epoch 20/20
429/429 [==============================] - 121s 283ms/step - loss: 0.0670 - acc:
0.9829 - val_loss: 0.0273 - val_acc: 0.9914
```

[29]:
```
## Visualizamos curvas de entrenamiento

plt.figure()
plt.title("Accuracy vs epochs")
plt.plot(history_cnn2.history['acc'])
plt.plot(history_cnn2.history['val_acc'])
plt.legend(['Training Accuracy', 'Validation Accuracy'])
plt.xlabel("Epoch")
plt.ylabel("Accuracy")


plt.figure()
plt.title("Loss vs epochs")
plt.plot(history_cnn2.history['loss'])
plt.plot(history_cnn2.history['val_loss'])
plt.legend(['Training Loss', 'Validation Loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss")
```

[29]:
```
Text(0,0.5,'Loss')
```


Accuracy vs epochs
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Accuracy
Training Accuracy
Validation Accuracy
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Epoch


Loss vs epochs
1.0
0.8
0.6
0.4
0.2
0.0
Loss
Training Loss
Validation Loss
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Epoch

[31]:
```
score_cnn2 = model_cnn2.evaluate(X_test, y_test, verbose=1)
print(f'Test Loss     : {score_cnn2[0]}')
print(f'Test Accuracy: {score_cnn2[1]}')
```

```
10000/10000 [==============================] - 6s 598us/step
Test Loss     : 0.03212649761128705
Test Accuracy: 0.9908
```

Ejercicio 5

Describa en detalle una posible aplicación de las redes convolucionales vistas en el taller a un problema de clasificación en ciencia, el estado o en la industria.

Atributador de Fashion

Una posible aplicacion de las redes convolucionales en la industria es un atributador de ropa, en el cual la red sea capaz de aprender si una remera es manga corta o manga largo, si tiene el cuello redondo o en escote V. Ademñas del color de la ropa.

Este uso es muy util en los ecommerce cuando alguien quiere vender una ropa pero no detalla las caracteristicas de la misma, siendo la red muy util en este caso ayudando a los usuarios a buscar prendas por sus atributos.

[ ]: