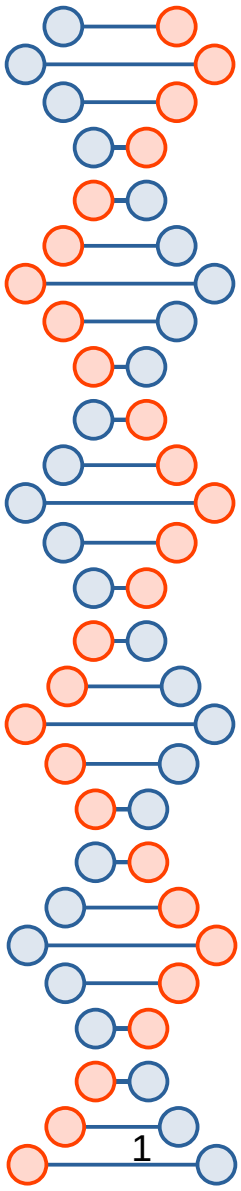
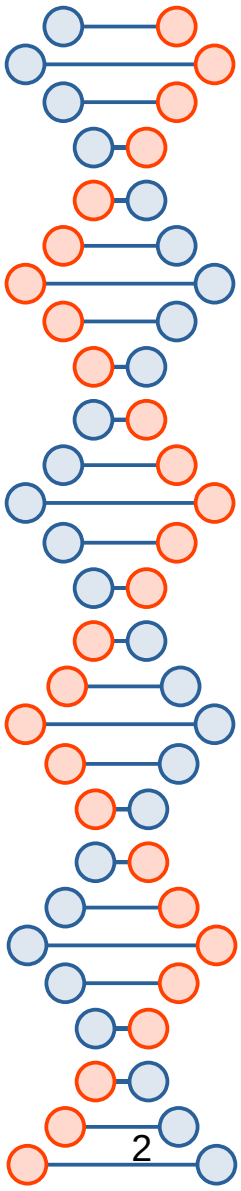
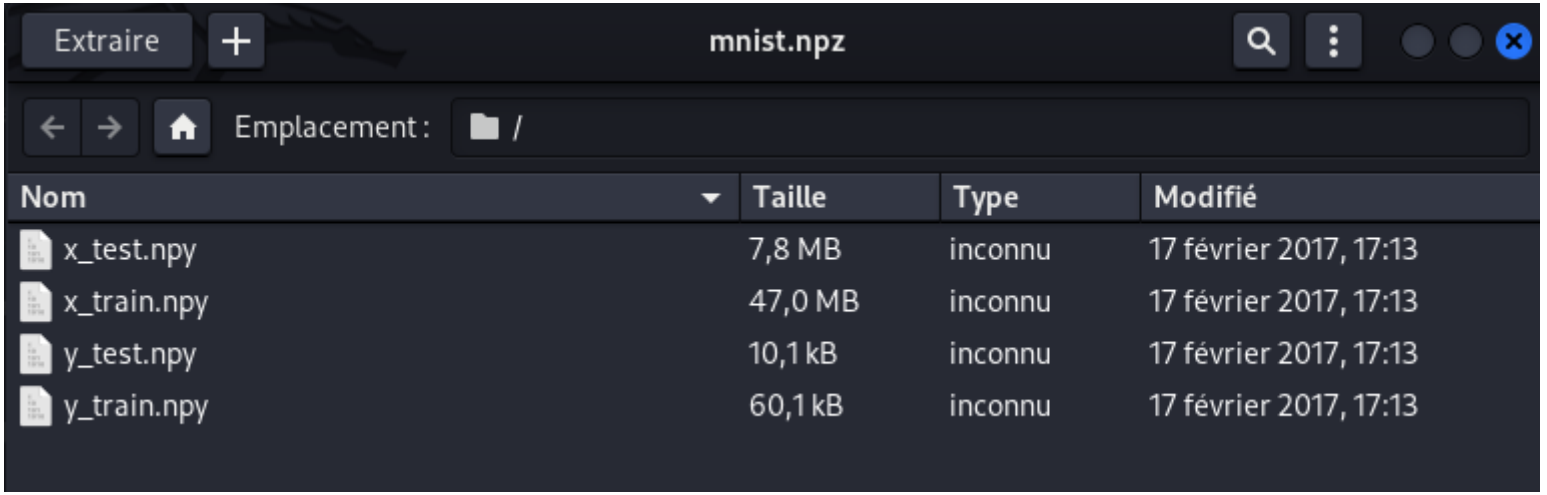


TP : Reconnaissance de chiffres avec un CNN



Principe

- Pour cet TP, nous allons créer un réseau de neurones convolutionnels capable de reconnaître les chiffres écrits à la main
- À partir d'une banque de 60000 images de chiffres écrits à la main (mnist de keras), nous allons entraîner 3 IA différentes et les comparer
- Ces IA seront différentes de par leur architecture CNN
- Le projet est trouvable sur https://github.com/Cirebla32/CNN_hand_written_numbers_recognition


Extraire
mnist.npz
Emplacement : /
Nom
Taille
Type
Modifié
x_test.npy
7,8 MB
inconnu
17 février 2017, 17:13
x_train.npy
47,0 MB
inconnu
17 février 2017, 17:13
y_test.npy
10,1 kB
inconnu
17 février 2017, 17:13
y_train.npy
60,1 kB
inconnu
17 février 2017, 17:13


Datasets
Machine Learning
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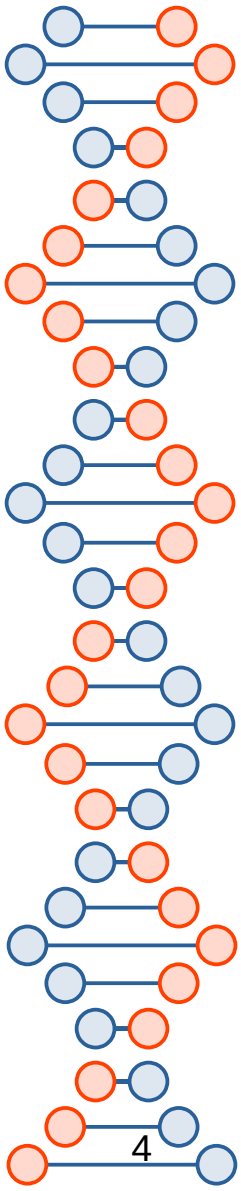

Cirebla32 / **CNN_hand_written_numbers_recognition** Public

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master | Go to file | Add file | Code

Cirebla32 completion of v2 codes ... 6 minutes ago 19

__pycache__	add of v2 of models and prepareData_	18 hours ago
data_examples	init	4 years ago
drawings	init	4 years ago
save_model	init	4 years ago
save_model_v2	completion of v2 codes	8 minutes ago
CNN_presentation.pdf	Add of dataset nmist.npz & presentations	2 weeks ago
Dataset.zip	Upload of the 10,000 first pictures in Dataset.zip	2 weeks ago
Layers_explanation.pdf	Add of dataset nmist.npz & presentations	2 weeks ago
README.md	completion of v2 codes	6 minutes ago
TP-CNN-architecture-1-1...	add of v2 of models and prepareData	19 hours ago
cnnutils.py	add of v2 of models and prepareData	19 hours ago
cnnutils_v2.py	completion of v2 codes	8 minutes ago
large-cnn-tutorial-keras....	init	4 years ago
large-cnn-tutorial-keras_...	completion of v2 codes	8 minutes ago
medium-cnn-tutorial-ker	init	4 years ago

medium-cnn-tutorial-ker...	init	4 years ago
medium-cnn-tutorial-ker...	completion of v2 codes	8 minutes ago
mnist.npz	Add of dataset nmist.npz & presentations	2 weeks ago
no-preparation-small-cn...	init	4 years ago
no-preparation-small-cn...	completion of v2 codes	8 minutes ago
preparedata.py	add of v2 of models and prepareData	19 hours ago
preparedata_v2.py	add of v2 of models and prepareData	19 hours ago
small-cnn-tutorial-keras....	add of v2 of models and prepareData	19 hours ago
small-cnn-tutorial-keras_...	completion of v2 codes	8 minutes ago

README.md

CNN_hand_written_numbers_recognition by ADJOVI Albéric | CHITOU Kader | IGABOUY CHOBLI Hermine | SOTOHOU Aristide

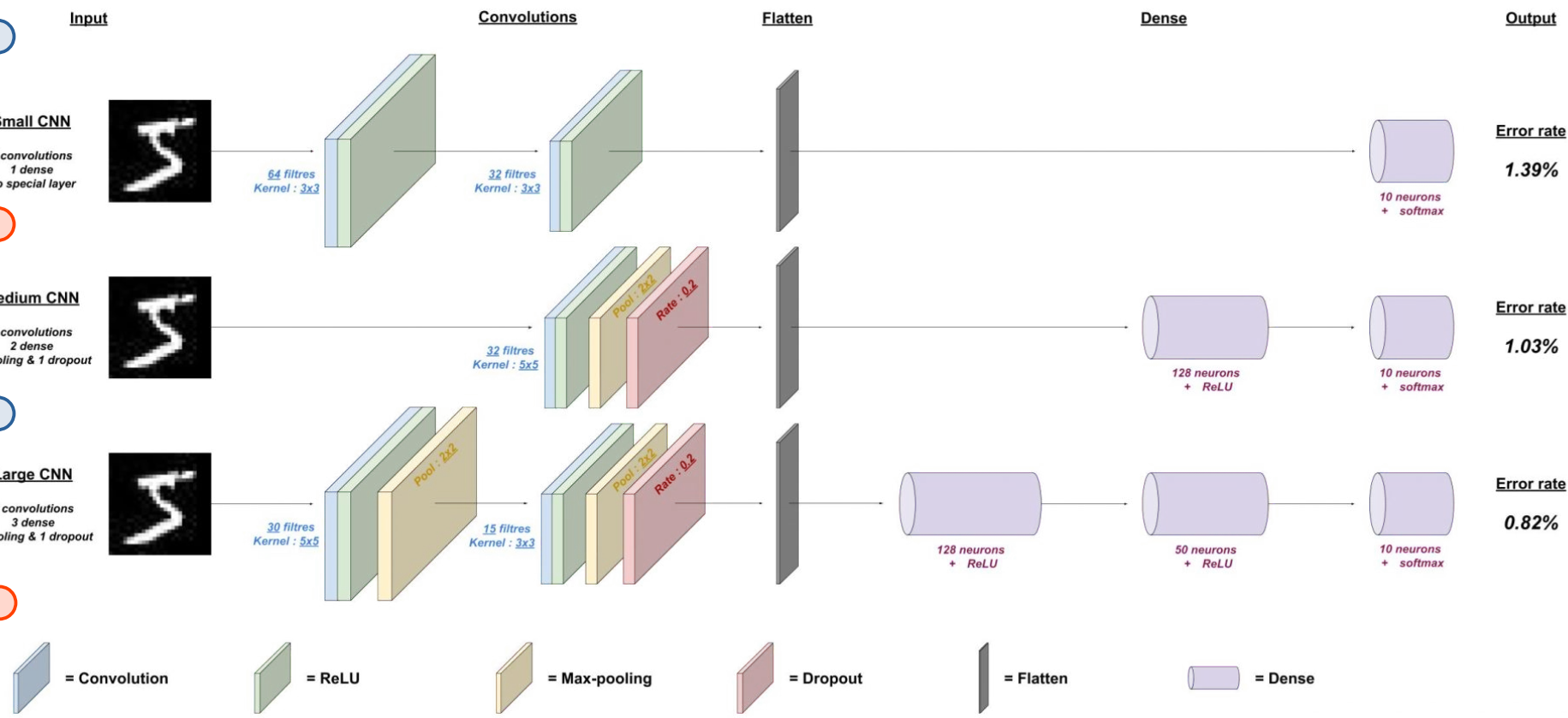
Command for running the project:

Pré-requis

- Python 3
- Pip 3
- Tensorflow
- Keras
- Matplotlib
- Pillow
- Numpy

```
git4@epac:~$ sudo apt install python3
git4@epac:~$ sudo apt install python3-pip
git4@epac:~$ pip3 install tensorflow
git4@epac:~$ pip3 install keras
git4@epac:~$ pip3 install matplotlib
git4@epac:~$ pip3 install pillow
git4@epac:~$ pip3 install numpy
```

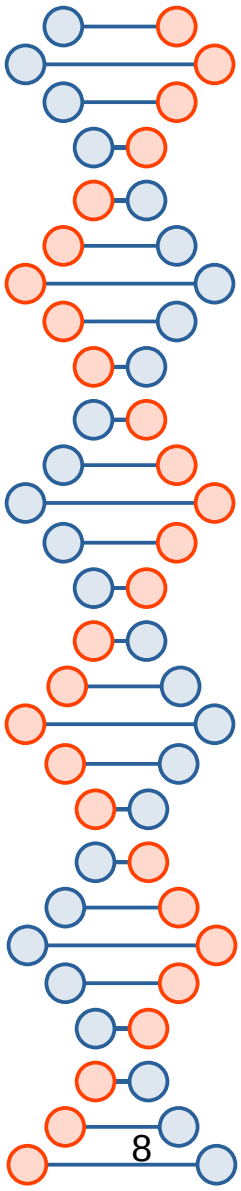
Architectures à réaliser



Organisation du code

Répertoires utiles

- **data_examples** : répertoire d'images d'apprentissage
- **drawings :** répertoire de chiffres tracés à la main pour tester le model
- **save_models_v2** : version fonctionnelle de save_models



Organisation du code

Fichiers utiles (.py)

- **cnnutils_v2** : fichier python contenant des fonctions utiles
- **preparedata_v2** : pré-traitement des données d'apprentissage
- **small-cnn-tutorial-keras_v2 :** le premier CNN implémenté et le plus simple des trois
- **medium-cnn-tutorial-keras_v2 :** le second CNN implémenté, avec l'ajout du pooling et du dropout
- **large-cnn-tutorial-keras_v2 :** le troisième CNN implémenté, plus complexe

preparedata_v2.py

- Importer les bibliothèques nécessaires

```
import numpy as np
from keras.datasets import mnist
from keras.utils import np_utils
```

- Empêcher le hasard dans l'exécution afin de tous obtenir un même résultat (à faire uniquement dans un cadre pédagogique)

```
seed = 7
np.random.seed(seed)
```

- Créer la fonction *get_and_prepare_data_mnist()* qui normalise les pixels et renvoient les labels sous forme de probabilités d'appartenance à une catégories

```
def get_and_prepare_data_mnist():
    ...
    return ...
```

preparedata_v2.py

- Contenu de *get_and_prepare_data_mnist()*

```
def get_and_prepare_data_mnist():
    # load data [mnist.npz downloadable on https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz]
    # it will be automatically downloaded by doing <mnist.load_data()> instead of the following
    (X_train, y_train), (X_test, y_test) = mnist.load_data("/path/to/mnist.npz")
    # reshape to be [samples][width][height][pixels] <==> [60000][28][28][1]
    X_train = X_train.reshape(X_train.shape[0], 28, 28, 1).astype('float32')
    X_test = X_test.reshape(X_test.shape[0], 28, 28, 1).astype('float32')
    # normalize inputs from 0-255 to 0-1
    X_train = X_train / 255
    X_test = X_test / 255
    # one hot encode outputs Ex : 5 <==> [0., 0., 0., 0., 0., 1., 0., 0., 0., 0.]
    y_train = np_utils.to_categorical(y_train)
    y_test = np_utils.to_categorical(y_test)
    num_classes = y_test.shape[1]
    return (X_train, y_train), (X_test, y_test), num_classes
```

small-cnn-tutorial-keras_v2.py

- Importer les bibliothèques nécessaires

```
import numpy as np
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers.convolutional import Conv2D, MaxPooling2D
import preparedata_v2 as pr
import cnnutils_v2 as cu
from os import  system
```

- Empêcher le hasard

```
seed = 7
np.random.seed(seed)
```

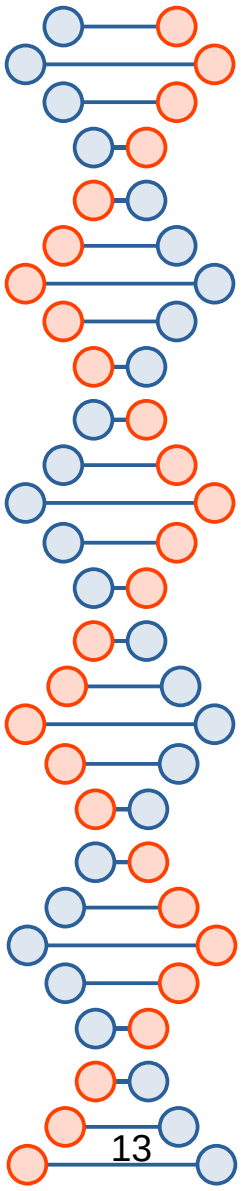
- Importer le Dataset

```
(X_train, y_train), (X_test, y_test), num_classes = pr.get_and_prepare_data_mnist()
```

small-cnn-tutorial-keras_v2.py

- Définir le modèle

```
def small_model():
    # create model
    model = Sequential()
    # build the model as shown on the image
    model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation='relu'))
    model.add(Conv2D(32, (3, 3), activation='relu'))
    model.add(Flatten())
    model.add(Dense(num_classes, activation='softmax'))
    # Compile model
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    return model
```



small-cnn-tutorial-keras_v2.py

- Construire, ajuster, évaluer et sauvegarder le modèle

```
# build the model
model = small_model()
# fit the model
model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=10, batch_size=200)
# evaluate the model
cu.print_model_error_rate(model, X_test, y_test)
# save the model
cu.save_keras_model(model, "save_model_v2/small_model_v2_cnn")
```

small-cnn-tutorial-keras_v2.py

- Exécution…

```
git4@epac:~$ python3 small-cnn-tutorial-keras_v2.py
```

```
2022-12-26 21:04:49.472077: W tensorflow/tsl/framework/cpu_allocator_impl.cc:82] Allocation of 188160000 exceeds 10% of free system memory.
Epoch 1/10
300/300 [==============================] - 148s 490ms/step - loss: 0.2310 - accuracy: 0.9327 - val_loss: 0.0666 - val_accuracy: 0.9786
Epoch 2/10
300/300 [==============================] - 147s 490ms/step - loss: 0.0652 - accuracy: 0.9810 - val_loss: 0.0578 - val_accuracy: 0.9806
Epoch 3/10
300/300 [==============================] - 145s 485ms/step - loss: 0.0468 - accuracy: 0.9856 - val_loss: 0.0468 - val_accuracy: 0.9850
Epoch 4/10
300/300 [==============================] - 147s 490ms/step - loss: 0.0352 - accuracy: 0.9891 - val_loss: 0.0492 - val_accuracy: 0.9843
Epoch 5/10
300/300 [==============================] - 147s 491ms/step - loss: 0.0279 - accuracy: 0.9913 - val_loss: 0.0460 - val_accuracy: 0.9869
Epoch 6/10
300/300 [==============================] - 148s 493ms/step - loss: 0.0209 - accuracy: 0.9935 - val_loss: 0.0516 - val_accuracy: 0.9845
Epoch 7/10
300/300 [==============================] - 148s 492ms/step - loss: 0.0160 - accuracy: 0.9951 - val_loss: 0.0486 - val_accuracy: 0.9866
Epoch 8/10
300/300 [==============================] - 148s 495ms/step - loss: 0.0117 - accuracy: 0.9963 - val_loss: 0.0493 - val_accuracy: 0.9863
Epoch 9/10
300/300 [==============================] - 147s 492ms/step - loss: 0.0091 - accuracy: 0.9973 - val_loss: 0.0516 - val_accuracy: 0.9854
Epoch 10/10
300/300 [==============================] - 148s 494ms/step - loss: 0.0077 - accuracy: 0.9975 - val_loss: 0.0607 - val_accuracy: 0.9856
Model score : 98.56%
Model error rate : 1.44%
```

small-cnn-tutorial-keras_v2.py

- Exécution de la version sans préparation…

```
git4@epac:~$ python3 no_preparation_small_cnn_tutorial_keras_v2.py
```

```
Epoch 1/10
1875/1875 [==============================] - 165s 87ms/step - loss: 0.2345 - accuracy: 0.9517 - val_loss: 0.0928 - val_accuracy: 0.9730
Epoch 2/10
1875/1875 [==============================] - 162s 86ms/step - loss: 0.0688 - accuracy: 0.9793 - val_loss: 0.0891 - val_accuracy: 0.9737
Epoch 3/10
1875/1875 [==============================] - 151s 81ms/step - loss: 0.0456 - accuracy: 0.9859 - val_loss: 0.0731 - val_accuracy: 0.9795
Epoch 4/10
1875/1875 [==============================] - 152s 81ms/step - loss: 0.0342 - accuracy: 0.9890 - val_loss: 0.1026 - val_accuracy: 0.9768
Epoch 5/10
1875/1875 [==============================] - 164s 87ms/step - loss: 0.0262 - accuracy: 0.9915 - val_loss: 0.1397 - val_accuracy: 0.9727
Epoch 6/10
1875/1875 [==============================] - 164s 87ms/step - loss: 0.0233 - accuracy: 0.9928 - val_loss: 0.1424 - val_accuracy: 0.9746
Epoch 7/10
1875/1875 [==============================] - 151s 81ms/step - loss: 0.0201 - accuracy: 0.9941 - val_loss: 0.1234 - val_accuracy: 0.9790
Epoch 8/10
1875/1875 [==============================] - 157s 84ms/step - loss: 0.0174 - accuracy: 0.9952 - val_loss: 0.1199 - val_accuracy: 0.9799
Epoch 9/10
1875/1875 [==============================] - 164s 88ms/step - loss: 0.0168 - accuracy: 0.9955 - val_loss: 0.1501 - val_accuracy: 0.9788
Epoch 10/10
1875/1875 [==============================] - 163s 87ms/step - loss: 0.0152 - accuracy: 0.9960 - val_loss: 0.1539 - val_accuracy: 0.9802
Model score : 98.02%
Model error rate : 1.98%
```

medium-cnn-tutorial-keras_v2.py

- Définir le modèle

```
def medium_model():
    # create model
    model = Sequential()
    # build the model as shown on the image
    model.add(Conv2D(32, (5, 5), input_shape=(28, 28, 1), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Dropout(0.2))
    model.add(Flatten())
    model.add(Dense(128, activation='relu'))
    model.add(Dense(num_classes, activation='softmax'))
    # Compile model
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    return model
```

medium-cnn-tutorial-keras_v2.py

- Exécution…

git4@epac:~$ python3 medium-cnn-tutorial-keras_v2.py

```
2022-12-27 16:41:07.774297: W tensorflow/tsl/framework/cpu_allocator_impl.cc:82] Allocation of 188160000 exceeds 10% of free system memory.
Epoch 1/10
300/300 [==============================] - ETA: 0s - loss: 0.2436 - accuracy: 0.93012022-12-27 16:41:46.995427: W tensorflow/tsl/framework/cpu
cation of 31360000 exceeds 10% of free system memory.
300/300 [==============================] - 37s 107ms/step - loss: 0.2436 - accuracy: 0.9301 - val_loss: 0.0791 - val_accuracy: 0.9768
Epoch 2/10
300/300 [==============================] - 28s 92ms/step - loss: 0.0740 - accuracy: 0.9778 - val_loss: 0.0534 - val_accuracy: 0.9836
Epoch 3/10
300/300 [==============================] - 28s 94ms/step - loss: 0.0530 - accuracy: 0.9836 - val_loss: 0.0419 - val_accuracy: 0.9860
Epoch 4/10
300/300 [==============================] - 28s 93ms/step - loss: 0.0420 - accuracy: 0.9869 - val_loss: 0.0356 - val_accuracy: 0.9882
Epoch 5/10
300/300 [==============================] - 28s 92ms/step - loss: 0.0331 - accuracy: 0.9893 - val_loss: 0.0359 - val_accuracy: 0.9871
Epoch 6/10
300/300 [==============================] - 28s 92ms/step - loss: 0.0285 - accuracy: 0.9912 - val_loss: 0.0347 - val_accuracy: 0.9882
Epoch 7/10
300/300 [==============================] - 28s 92ms/step - loss: 0.0230 - accuracy: 0.9927 - val_loss: 0.0374 - val_accuracy: 0.9883
Epoch 8/10
300/300 [==============================] - 28s 93ms/step - loss: 0.0200 - accuracy: 0.9938 - val_loss: 0.0343 - val_accuracy: 0.9885
Epoch 9/10
300/300 [==============================] - 28s 93ms/step - loss: 0.0175 - accuracy: 0.9944 - val_loss: 0.0332 - val_accuracy: 0.9893
Epoch 10/10
300/300 [==============================] - 28s 93ms/step - loss: 0.0144 - accuracy: 0.9952 - val_loss: 0.0324 - val_accuracy: 0.9895
2022-12-27 16:45:59.199577: W tensorflow/tsl/framework/cpu_allocator_impl.cc:82] Allocation of 31360000 exceeds 10% of free system memory.
Model score : 98.95%
Model error rate : 1.05%
```

large-cnn-tutorial-keras_v2.py

- Définir le modèle

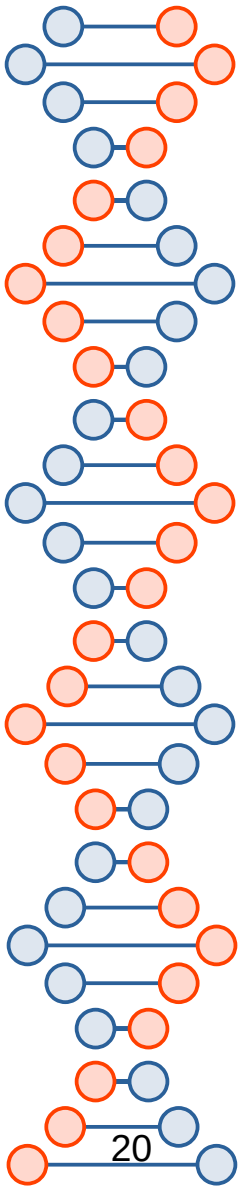
```
def large_model():
    # create model
    model = Sequential()
    # build the model as shown on the image
    model.add(Conv2D(30, (5, 5), input_shape=(28, 28, 1), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Conv2D(15, (3, 3), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Dropout(0.2))
    model.add(Flatten())
    model.add(Dense(128, activation='relu'))
    model.add(Dense(50, activation='relu'))
    model.add(Dense(num_classes, activation='softmax'))
    # Compile model
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    return model
```

large-cnn-tutorial-keras_v2.py

- Exécution…

git4@epac:~$ python3 large-cnn-tutorial-keras_v2.py

```
2022-12-27 16:47:13.786310: W tensorflow/tsl/framework/cpu_allocator_impl.cc:82] Allocation of 188160000 exceeds 10% of free system memory
Epoch 1/10
300/300 [==============================] - 31s 98ms/step - loss: 0.3670 - accuracy: 0.8878 - val_loss: 0.0721 - val_accuracy: 0.9772
Epoch 2/10
300/300 [==============================] - 29s 96ms/step - loss: 0.0903 - accuracy: 0.9724 - val_loss: 0.0483 - val_accuracy: 0.9847
Epoch 3/10
300/300 [==============================] - 29s 95ms/step - loss: 0.0663 - accuracy: 0.9795 - val_loss: 0.0340 - val_accuracy: 0.9882
Epoch 4/10
300/300 [==============================] - 28s 95ms/step - loss: 0.0548 - accuracy: 0.9829 - val_loss: 0.0339 - val_accuracy: 0.9890
Epoch 5/10
300/300 [==============================] - 29s 95ms/step - loss: 0.0473 - accuracy: 0.9857 - val_loss: 0.0271 - val_accuracy: 0.9901
Epoch 6/10
300/300 [==============================] - 29s 95ms/step - loss: 0.0405 - accuracy: 0.9870 - val_loss: 0.0285 - val_accuracy: 0.9903
Epoch 7/10
300/300 [==============================] - 29s 95ms/step - loss: 0.0359 - accuracy: 0.9885 - val_loss: 0.0255 - val_accuracy: 0.9919
Epoch 8/10
300/300 [==============================] - 29s 95ms/step - loss: 0.0345 - accuracy: 0.9893 - val_loss: 0.0234 - val_accuracy: 0.9922
Epoch 9/10
300/300 [==============================] - 29s 97ms/step - loss: 0.0312 - accuracy: 0.9899 - val_loss: 0.0258 - val_accuracy: 0.9916
Epoch 10/10
300/300 [==============================] - 28s 95ms/step - loss: 0.0287 - accuracy: 0.9908 - val_loss: 0.0250 - val_accuracy: 0.9914
Model score : 99.14%
Model error rate : 0.86%
```



cnnutils_v2.py

Fonctions de cnnutils

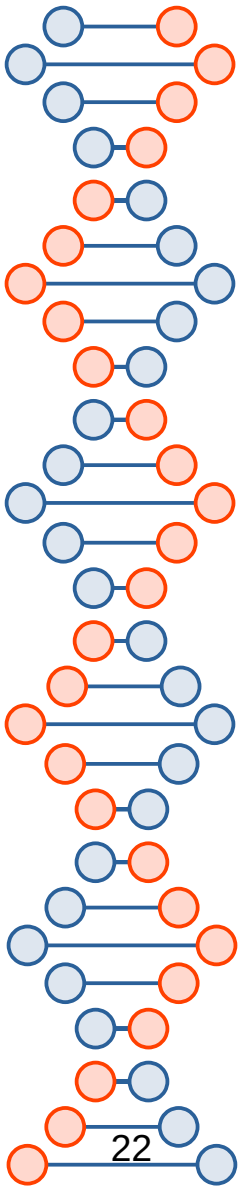
- def **save_keras_model**(model, filename)
- def **load_keras_model**(filename)
- def **print_model_error_rate**(model, X_test, y_test)
- def **export_image_from_dataset**(data, filename)
- def **plot_image_from_dataset**(data, filename)
- def **import_custom_image_to_dataset**(filename)

Testons le modèle

```
git4@epac:~$ python3
>>> import cnnutils_v2 as cu
>>> model = cu.load_keras_model("save_model_v2/large_model_v2_cnn")
>>> model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
>>> x = cu.import_custom_image_to_dataset("drawings/9.jpg")
>>> model.predict(x)
```

Remarques :

- Les images utilisées pour l'entraînement ont subit un prétraitement. Leur fond est noir
- Le modèle fournit donc de meilleurs résultats si l'image en entrée présente des caractéristiques similaires. Il est utile de pré-traiter les images avant toute prédiction.



Merci pour votre aimable attention…