CS 615 – Deep Learning

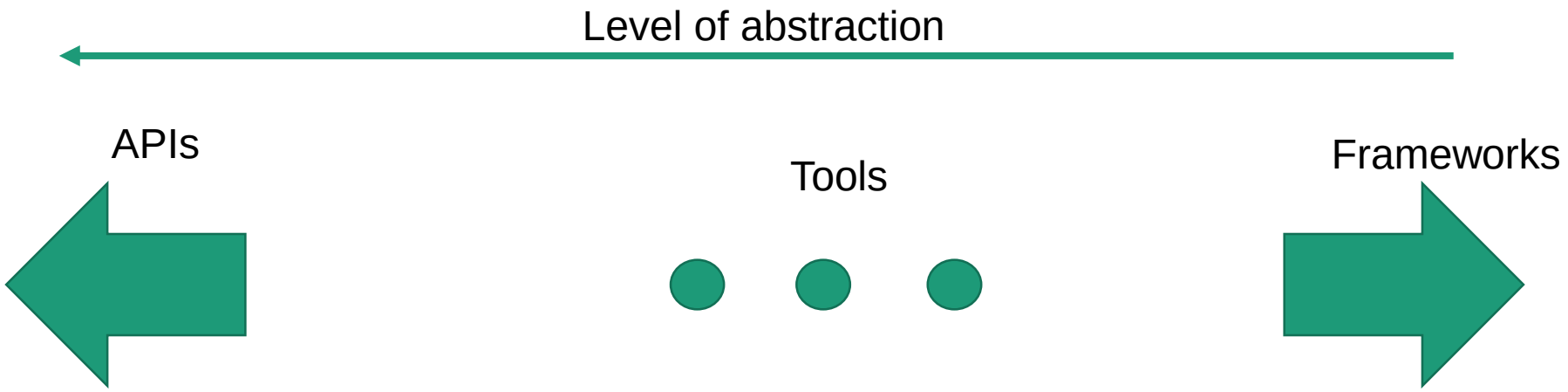
ML/DL APIs

Content largely created by Maryam Daniali

ML/DL APIs

- From the onset of this class we said we'd be learning the foundations of deep learning.
  - And therefore learning where they came from and implementing some from scratch.
  - After all, as computer scientists we should be the ones coming up with these algorithms!
- Of course, often "off the shelf" existing solutions may be useful
  - Or at least a starting point.
- So let's start by doing a quick survey of some of the most popular ML/DL APIs.

Machine learning tools



Targeted towards:
Application developers
Pre-trained models with a single API request

Ex: Machine learning APIs such as Google Vision Cloud, Azure Cognitive Services

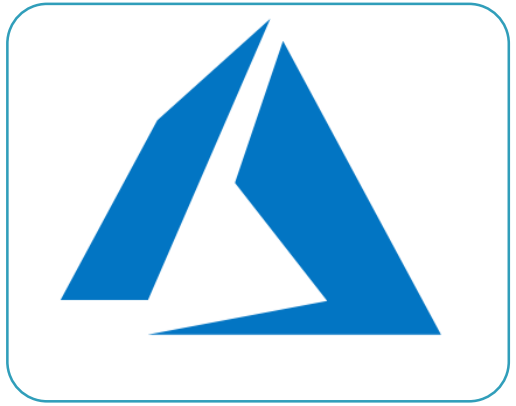
Something in between
Train and serve custom models, no model code required

Ex:
AutoML (Google)
ML.Net(Microsoft)

Targeted towards: Data scientists and ML practitioners

Ex: TensorFlow, Sklearn, PyTorch

3 Most Well-known ML APIs



Google Cloud Machine Learning API

+Good amount of data for pre-training

You can code your own model.

Also, contains 5 APIs that give access to pre-trained models to accomplish common machine learning tasks

1)Cloud Vision

2) Cloud Video Intelligence

3) Cloud Speech

4) Cloud Natural Language

5) Cloud Translation

Microsoft Azure Machine Learning API

+Easy for beginners to work with

You can code your own model or use services for ML with less code needed.

Amazon Machine Learning API

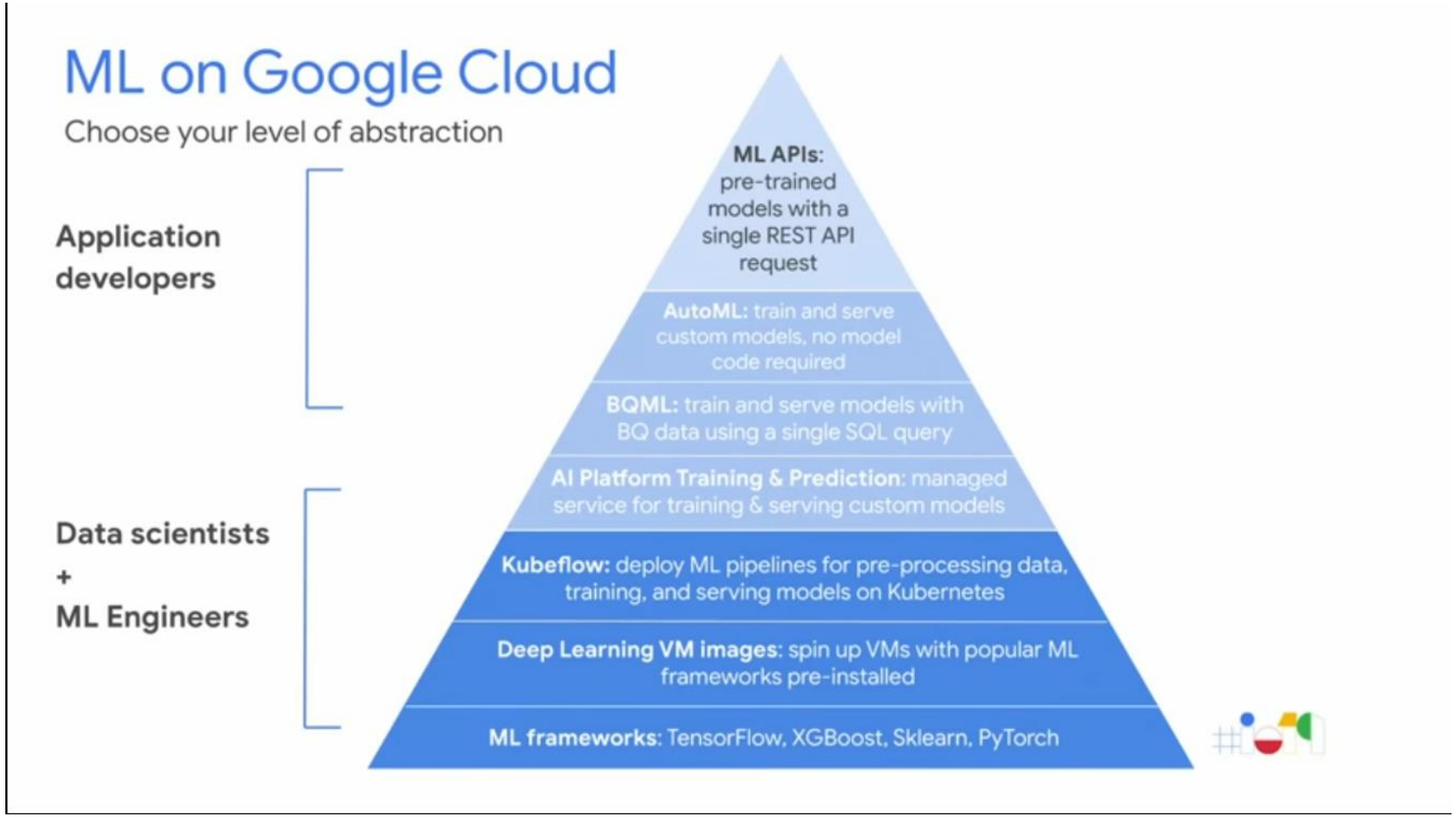
+Affordable prices, many functions for free

Pay as you go (only for what you use).

You can code your own model or use services for ML with less code needed.

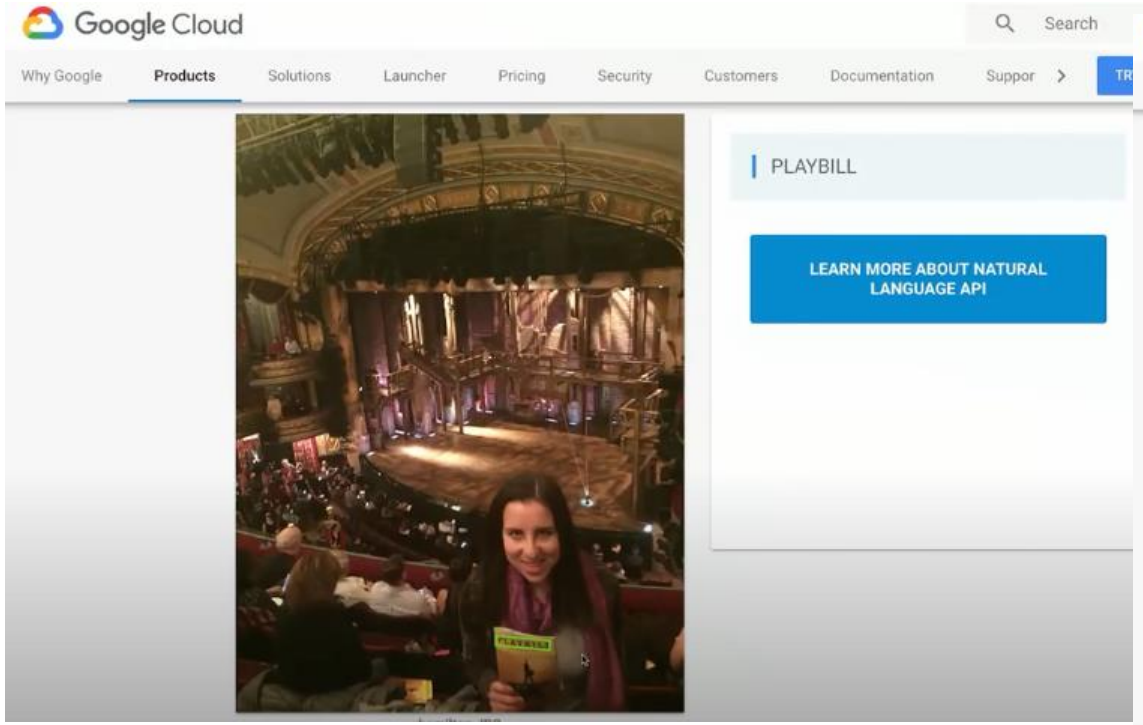
https://rapidapi.com/blog/top-machine-learning-apis/

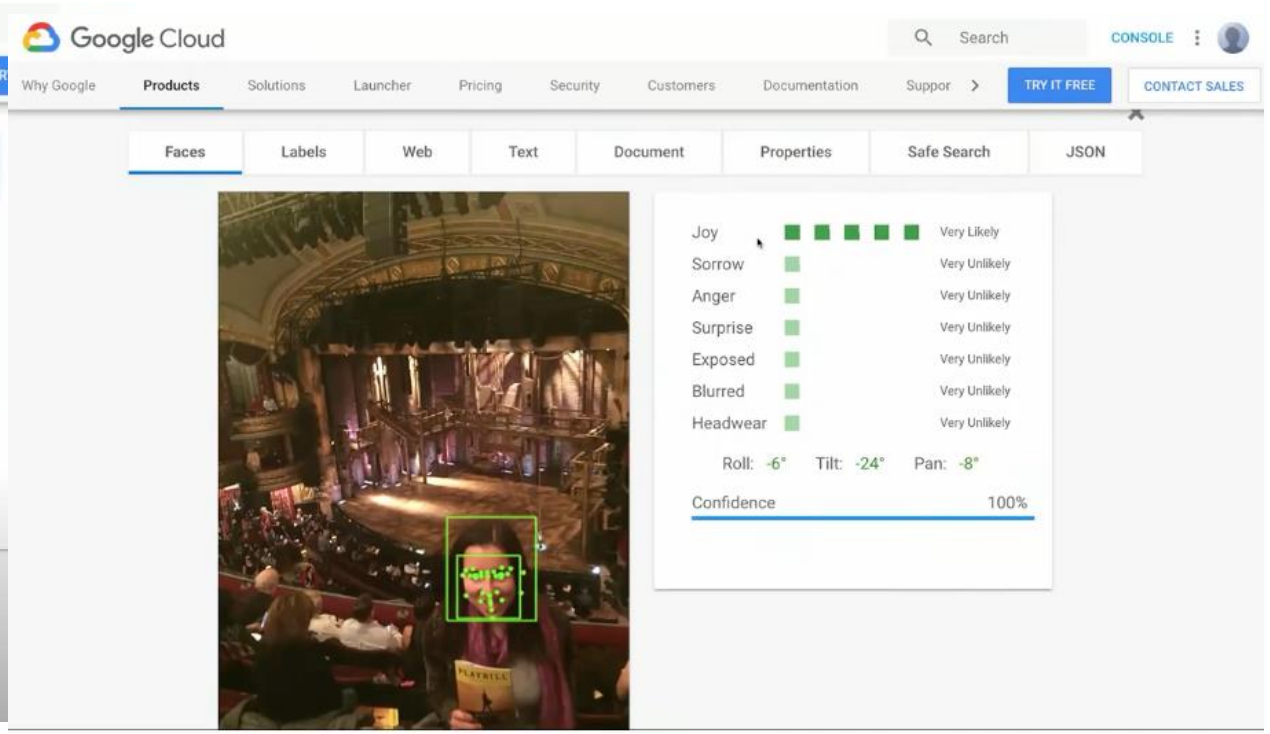
Google Cloud ML abstraction Hierarchy



Results of Google Clould Vision API on a sample image

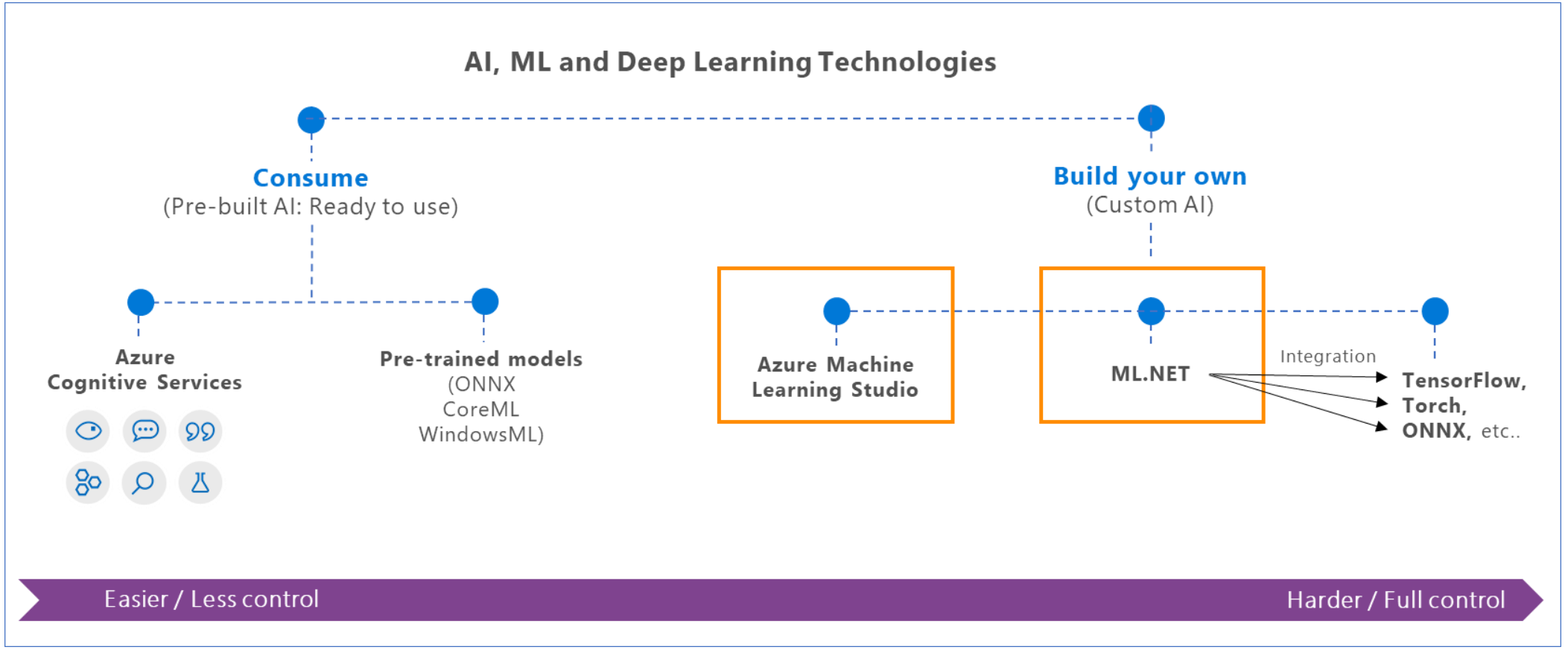
- Based on the feature detection in the request, it detected the face and the feeling as well as the text on the playbill.





https://youtu.be/gVz9jKE_9iU

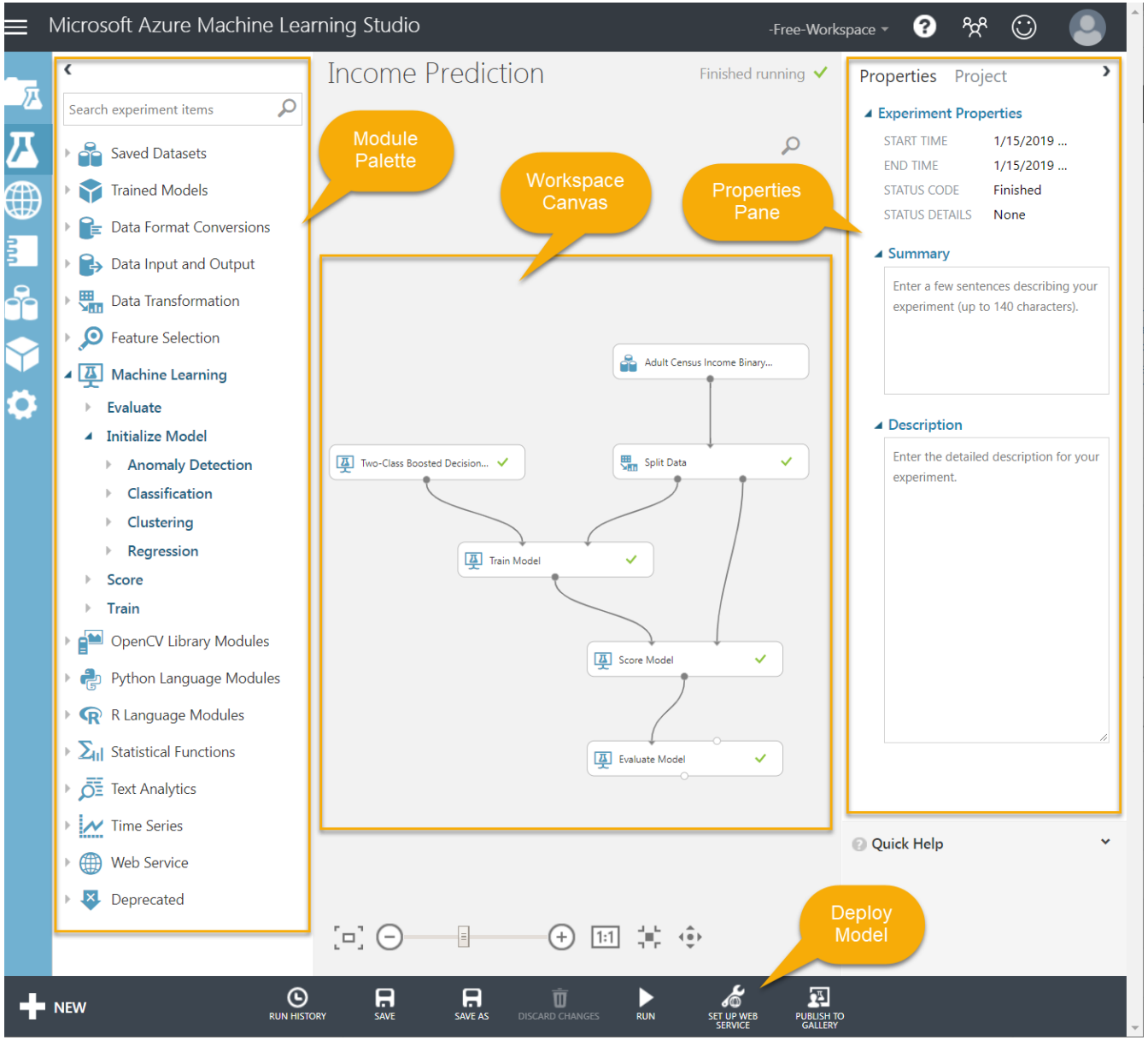
Microsoft Azure ML Hierarchy



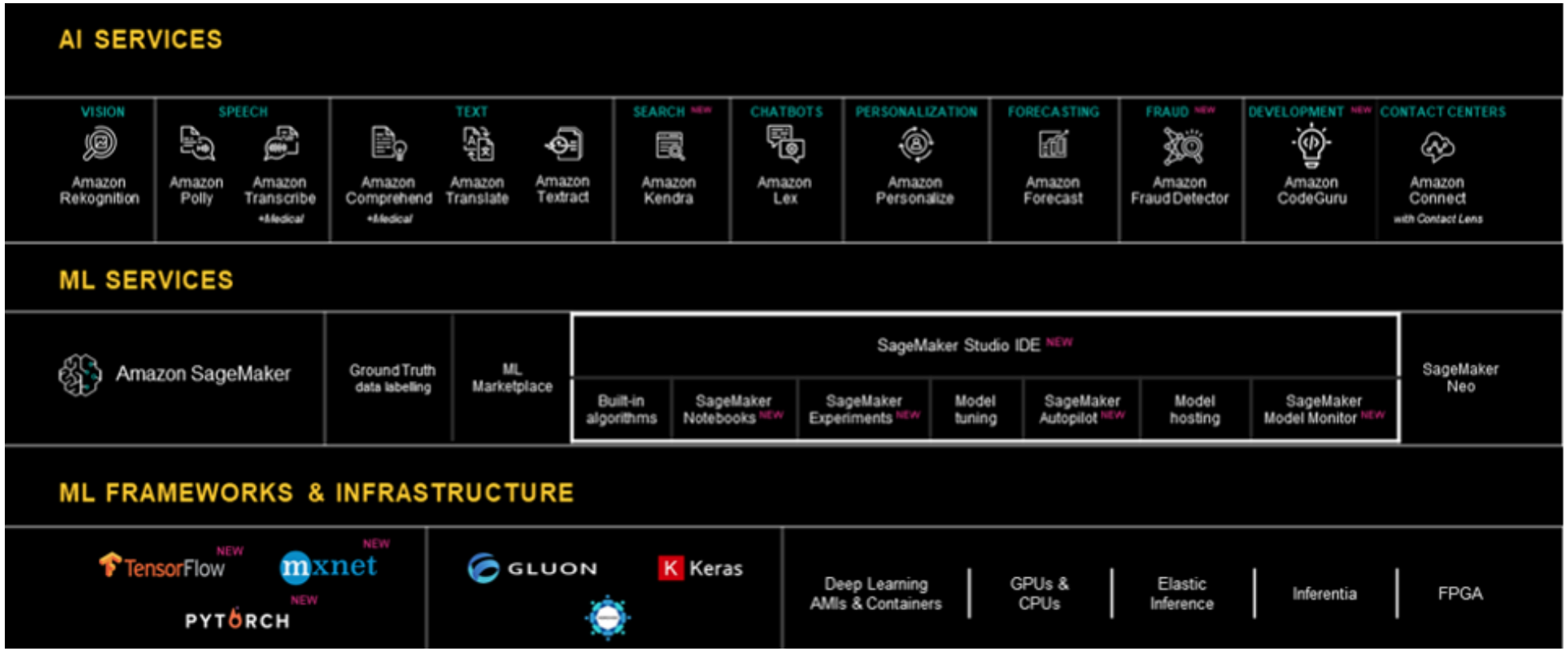
https://devblogs.microsoft.com/premier-developer/custom-ai-models-with-azure-machine-learning-studio-and-ml-net/

Azure Machine Learning Studio

- A drag-and-drop graphical user interface

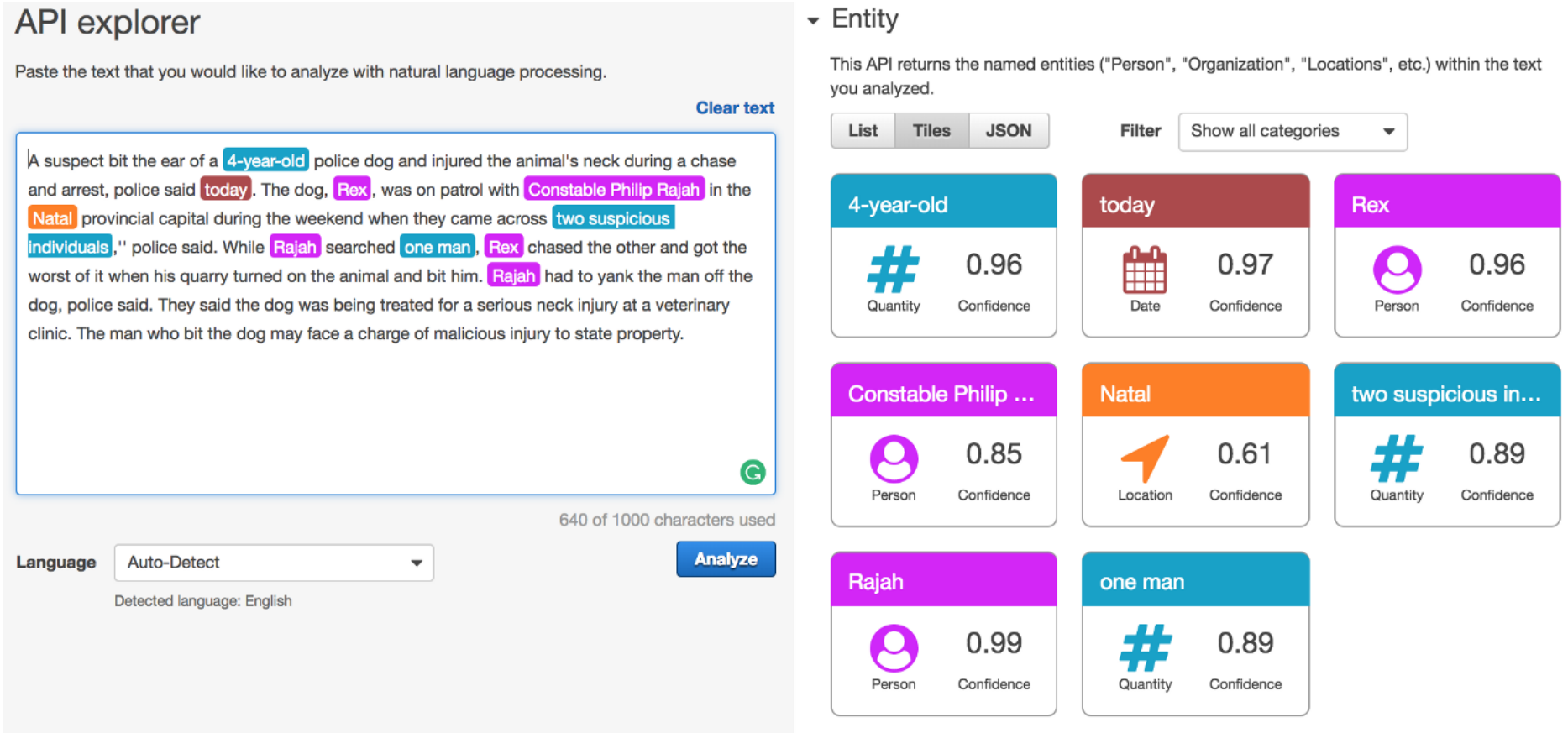


AWS ML Hierarchy



https://specials-images.forbesimg.com/imageserve/5e6017d8e1e617000758dc82/960x0.jpg?fit=scale

Ex: Amazon Comprehend (NLP)



https://medium.com/@julsimon/a-quick-look-at-natural-language-processing-with-amazon-comprehend-238b8d9ec11d

Using the APIs Programmatically

- Of course each of these APIs can be used programmatically.
- Ex: Google Cloud Vision API

```
# Imports the Google Cloud client library
from google.cloud import vision
from google.cloud.vision import types


# Instantiates a client
client = vision.ImageAnnotatorClient()


# Performs label detection on the image file
response =
client.label_detection(image=image_filename)
labels = response.label_annotations
```

Calling the Vision API in Python. Now, calling the vision API in python. Can be the language of your choice!

Some Other Popular ML APIs to look up

- IBM Watson
- Alchemy
- Google Prediction
- Wit.ai
- BigML

ML frameworks

- ML Frameworks are more geared towards people (scientists) wanting to train and build their system from scratch.
- Some of the most popular ones include:
  - TensorFlow
  - PyTorch
  - Scikit-learn
  - Weka
  - Keras

TensorFlow

- Google Brain's second-generation system.
- Can run on multiple CPUs and GPUs (with optional CUDA and SYCL extensions).
- Allows for the easy deployment of computation across platforms (CPUs, GPUs, TPUs), and from desktops to clusters of servers to mobile and edge devices.
- **Written in:** Python, C++, CUDA
- **Operating system:** Linux, macOS, Windows, Android, and iOS.

```
from __future__ import division, print_function, absolute_import

import tflearn

# Data loading and preprocessing
import tflearn.datasets.mnist as mnist
X, Y, testX, testY = mnist.load_data(one_hot=True)

# Building deep neural network
input_layer = tflearn.input_data(shape=[None, 784])
dense1 = tflearn.fully_connected(input_layer, 64, activation='tanh',
                                 regularizer='L2', weight_decay=0.001)
dropout1 = tflearn.dropout(dense1, 0.8)
dense2 = tflearn.fully_connected(dropout1, 64, activation='tanh',
                                 regularizer='L2', weight_decay=0.001)
dropout2 = tflearn.dropout(dense2, 0.8)
softmax = tflearn.fully_connected(dropout2, 10, activation='softmax')

# Regression using SGD with learning rate decay and Top-3 accuracy
sgd = tflearn.SGD(learning_rate=0.1, lr_decay=0.96, decay_step=1000)
top_k = tflearn.metrics.Top_k(3)
net = tflearn.regression(softmax, optimizer=sgd, metric=top_k,
                         loss='categorical_crossentropy')

# Training
model = tflearn.DNN(net, tensorboard_verbose=0)
```

Deep Neural Network for MNIST dataset classification task
Using TensorFlow

https://github.com/tflearn/tflearn/blob/master/examples/images/dnn.py

PyTorch

- Is an open source machine learning library based on the Torch library
- Can be used for computer vision and natural language processing applications
- Is developed by Facebook's AI Research lab (FAIR).
- Is free and open-source software
- **Written in:** Python, C++
- **Operating system:** Linux, macOS, Windows

```
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
```

✓ 0.2s PyTorch & TorchVision (Python) PyTorch Install

```
class Net(nn.Module):
    def __init__(self):
        super(Net, self).__init__()
        self.conv1 = nn.Conv2d(1, 10, kernel_size=5)
        self.conv2 = nn.Conv2d(10, 20, kernel_size=5)
        self.conv2_drop = nn.Dropout2d()
        self.fc1 = nn.Linear(320, 50)
        self.fc2 = nn.Linear(50, 10)

    def forward(self, x):
        x = F.relu(F.max_pool2d(self.conv1(x), 2))
        x = F.relu(F.max_pool2d(self.conv2_drop(self.conv2(x)), 2))
        x = x.view(-1, 320)
        x = F.relu(self.fc1(x))
        x = F.dropout(x, training=self.training)
        x = self.fc2(x)
        return F.log_softmax(x)
```

✓ 0.2s Creating the Network | PyTorch & TorchVision (Python) PyTorch Install

```
network = Net()
optimizer = optim.SGD(network.parameters(), lr=learning_rate,
                      momentum=momentum)
```

✓ 0.2s Network & Optimizer Setup | PyTorch & TorchVision (Python) PyTorch Install

```
train_losses = []
train_counter = []
test_losses = []
test_counter = [i*len(train_loader.dataset) for i in range(n_epochs + 1)]
```

✓ 0.2s PyTorch & TorchVision (Python) PyTorch Install

```
def train(epoch):
  network.train()
  for batch_idx, (data, target) in enumerate(train_loader):
    optimizer.zero_grad()
    output = network(data)
    loss = F.nll_loss(output, target)
    loss.backward()
    optimizer.step()
    if batch_idx % log_interval == 0:
      print('Train Epoch: {} [{}/{} ({:.0f}%)]\tLoss: {:.6f}'.format(
        epoch, batch_idx * len(data), len(train_loader.dataset),
        100. * batch_idx / len(train_loader), loss.item()))
      train_losses.append(loss.item())
      train_counter.append(
        (batch_idx*64) + ((epoch-1)*len(train_loader.dataset)))
      torch.save(network.state_dict(), '/results/model.pth')
      torch.save(optimizer.state_dict(), '/results/optimizer.pth')
```

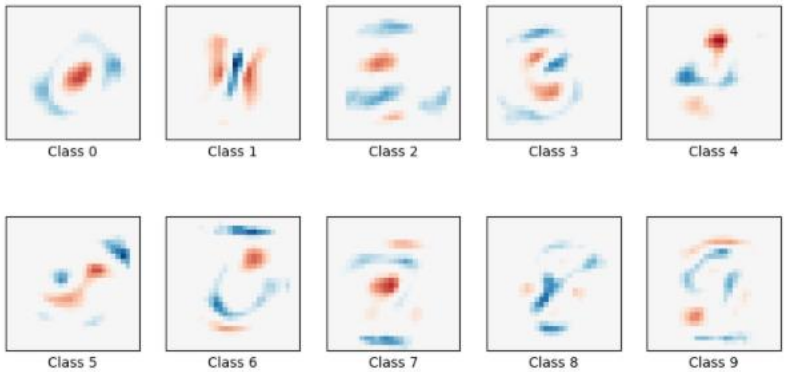
Deep Neural Network for MNIST dataset classification task Using PyTorch

Scikit-learn (also known as sklearn)

- Is a free machine learning library for Python.
- Performs classification, regression, and clustering algorithms, including support vector machines, random forests, etc.
- Interoperate with NumPy and SciPy.
- Started as scikits.learn, a Google Summer of Code project by David Cournapeau.
- **Written in:** Python, Cython, C, C++
- **Operating system:** Linux, macOS, Windows

MNIST classification by multinomial logistic + L1 Using Scikit-learn

```python
import time
import matplotlib.pyplot as plt
import numpy as np

from sklearn.datasets import fetch_openml
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.utils import check_random_state

print(__doc__)

# Author: Arthur Mensch <arthur.mensch@m4x.org>
# License: BSD 3 clause

# Turn down for faster convergence
t0 = time.time()
train_samples = 5000

# Load data from https://www.openml.org/d/554
X, y = fetch_openml('mnist_784', version=1, return_X_y=True)

random_state = check_random_state(0)
permutation = random_state.permutation(X.shape[0])
X = X[permutation]
y = y[permutation]
X = X.reshape((X.shape[0], -1))

X_train, X_test, y_train, y_test = train_test_split(
    X, y, train_size=train_samples, test_size=10000)

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)

# Turn up tolerance for faster convergence
clf = LogisticRegression(
    C=50. / train_samples, penalty='l1', solver='saga', tol=0.1
)
clf.fit(X_train, y_train)
sparsity = np.mean(clf.coef_ == 0) * 100
score = clf.score(X_test, y_test)
# print('Best C % .4f' % clf.C_)
print("Sparsity with L1 penalty: %.2f%%" % sparsity)
print("Test score with L1 penalty: %.4f" % score)

coef = clf.coef_.copy()
plt.figure(figsize=(10, 5))
scale = np.abs(coef).max()
for i in range(10):
    l1_plot = plt.subplot(2, 5, i + 1)
    l1_plot.imshow(coef[i].reshape(28, 28), interpolation='nearest',
                   cmap=plt.cm.RdBu, vmin=-scale, vmax=scale)
    l1_plot.set_xticks(())
    l1_plot.set_yticks(())
    l1_plot.set_xlabel('Class %i' % i)
plt.suptitle('Classification vector for...')

run_time = time.time() - t0
print('Example run in %.3f s' % run_time)
plt.show()
```

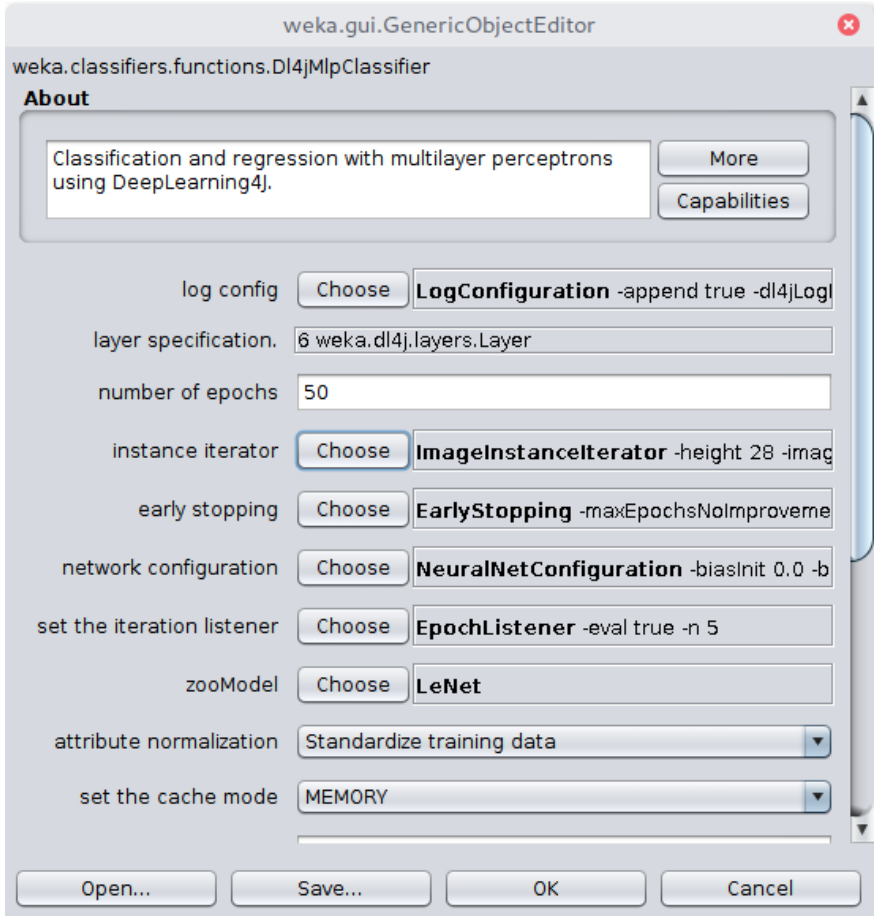


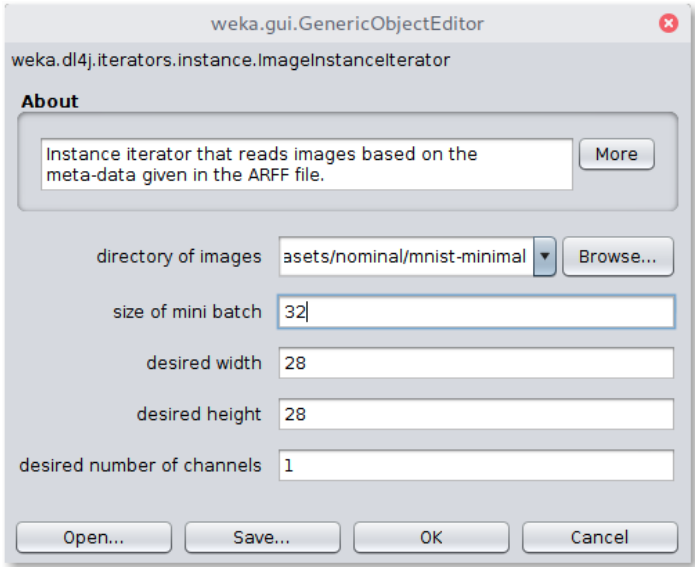
Ref: https://scikit-learn.org/stable/auto_examples/linear_model/plot_sparse_logistic_regression_mnist.html?highlight=mnist

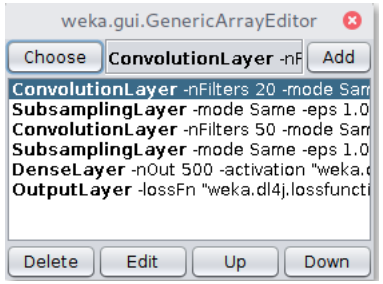
Weka

- **Weka** is an open source machine learning software
- Can be accessed through a GUI, terminal, or a Java API.
- Contains built-in tools for standard machine learning tasks
- Gives transparent access to well-known toolboxes such as scikit-learn, R, and Deeplearning4j.
- **Written in:** Java
- **Operating system:** Linux, OS X, Windows

Classifying MNIST dataset using Weka



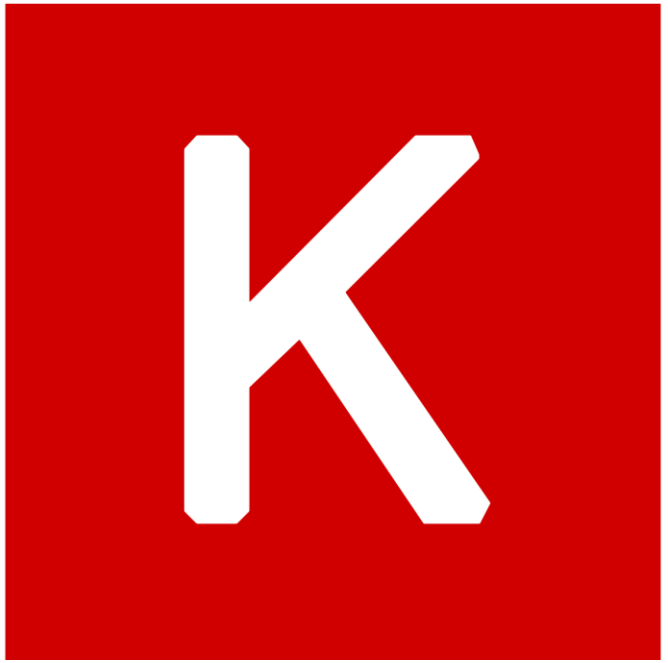




https://deeplearning.cms.waikato.ac.nz/examples/classifying-mnist/

Keras

- **Keras** is an open-source neural-network library written in Python.
- Can run on top of TensorFlow, Microsoft Cognitive Toolkit, R, Theano, and PlaidML.
- Enables fast experimentation with deep neural networks
- Focuses on being user-friendly, modular, and extensible.
- **Written in:** Python
- **Operating system:** Cross-platform



Deep Neural Network for MNIST dataset classification task Using Keras

```
from __future__ import print_function
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras import backend as K

batch_size = 128
num_classes = 10
epochs = 12

# input image dimensions
img_rows, img_cols = 28, 28

# the data, split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()

if K.image_data_format() == 'channels_first':
    x_train = x_train.reshape(x_train.shape[0], 1, img_rows, img_cols)
    x_test = x_test.reshape(x_test.shape[0], 1, img_rows, img_cols)
    input_shape = (1, img_rows, img_cols)
else:
    x_train = x_train.reshape(x_train.shape[0], img_rows, img_cols, 1)
    x_test = x_test.reshape(x_test.shape[0], img_rows, img_cols, 1)
    input_shape = (img_rows, img_cols, 1)

x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')

# convert class vectors to binary class matrices
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss=keras.losses.categorical_crossentropy,
              optimizer=keras.optimizers.Adadelta(),
              metrics=['accuracy'])

model.fit(x_train, y_train,
          batch_size=batch_size,
          epochs=epochs,
          verbose=1,
          validation_data=(x_test, y_test))
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

https://keras.io/examples/mnist_cnn/

References

- https://blog.rapidapi.com/top-machine-learning-apis/
- https://blog.exxactcorp.com/tensorflow-vs-pytorch-vs-keras-for-nlp/
- https://towardsdatascience.com/the-most-useful-ml-tools-2020-e41b54061c58
- https://en.wikipedia.org/wiki/