Machine Learning with Java? Deeplearning4j!

Enrique Llerena Dominguez

Java Forum Stuttgart 2020

$whoami

- Enrique Llerena Dominguez
- Senior Software Engineer / Consultant @ mimacom
- Experience developing software for the finance, retail, pharma, and automotive industry

- Professional Interests: Software Architecture, Cloud Computing, Artificial Intelligence

- Free Time: Spending time with my kids, watching football, learning german, and developing nice things

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MIMACOM

Image source: Photo by dylan nolte on Unsplash

Agenda

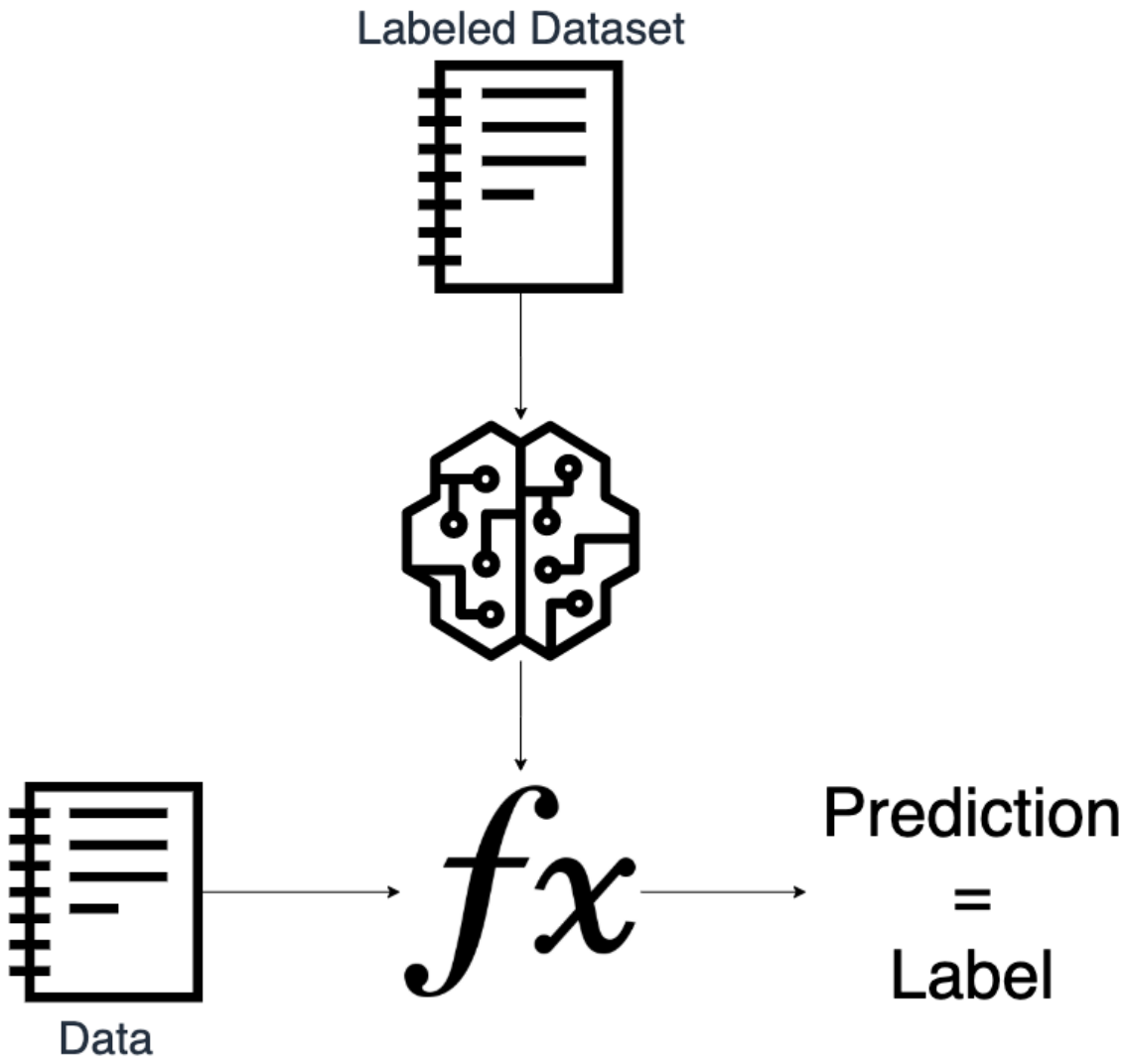
- Machine Learning 101 + deeplearning4j
- Deeplearning4j integrations
- Hands on examples:
  - Image classification – Approach and code
  - Sentiment analysis – Approach and code

What is Machine Learning?

- Machine Learning is the study of computer algorithms that improve automatically through experience

Source: Mitchell, T. (1997), Machine Learning. http://www.cs.cmu.edu/~tom/mlbook.html , retrieved 08.2020

What is Machine Learning?



What is Deeplearning4j?

Open-source deep-learning library
written for Java and Scala

Story time!

Iris classification AKA the “Machine Learning Hello World”

Peter the biologist

Image source: Photo by Alex on Unsplash

Image source: https://en.wikipedia.org/wiki/Gasp%C3%A9_Peninsula

Images source:https://en.wikipedia.org/wiki/Iris_flower_data_set

Iris Virginica

Iris Setosa

Iris Versicolor

Images source: https://en.wikipedia.org/wiki/Iris_flower_data_set

Image source: Photo by Blaz Erzetic on Unsplash

Images source: Photo by Ben Mullins on Unsplash

Images source:Photo by Jarritos Mexican Soda on Unsplash

Image source: Photo by Alex on Unsplash

Teresa the software engineer, Peter’s daughter

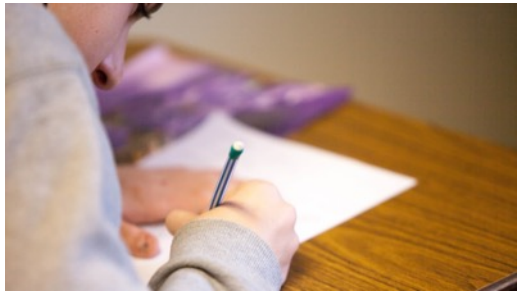
Photo by Jarritos Mexican Soda on Unsplash

Photo by Jarritos Mexican Soda on Unsplash

Photo by Jarritos Mexican Soda on Unsplash

Photo by NESA by Makers on Unsplash

Resources



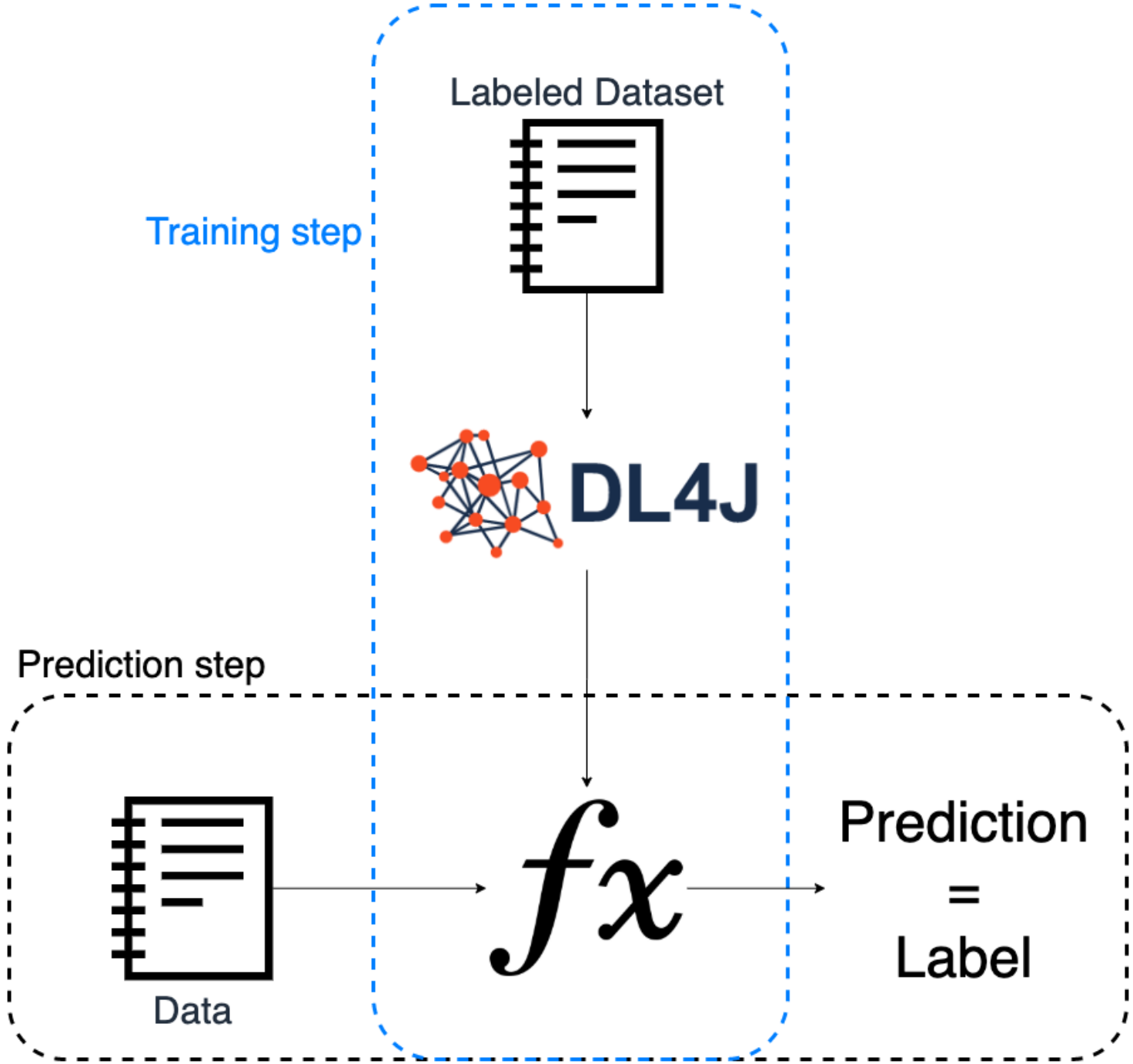
Labeled dataset

Images sources:
Photo by Ben Mullins on Unsplash
Deeplearning4j Logo https://github.com/eclipse/deeplearning4j
Java Logo, By Source (WP:NFCC#4), Fair use, https://en.wikipedia.org/w/index.php?curid=51298819
Maven Logo, By Apache Software Foundation - Apache Software Foundation http://maven.apache.org/images/maventxt_logo_200.gif, Attribution, https://commons.wikimedia.org/w/index.php?curid=10365467

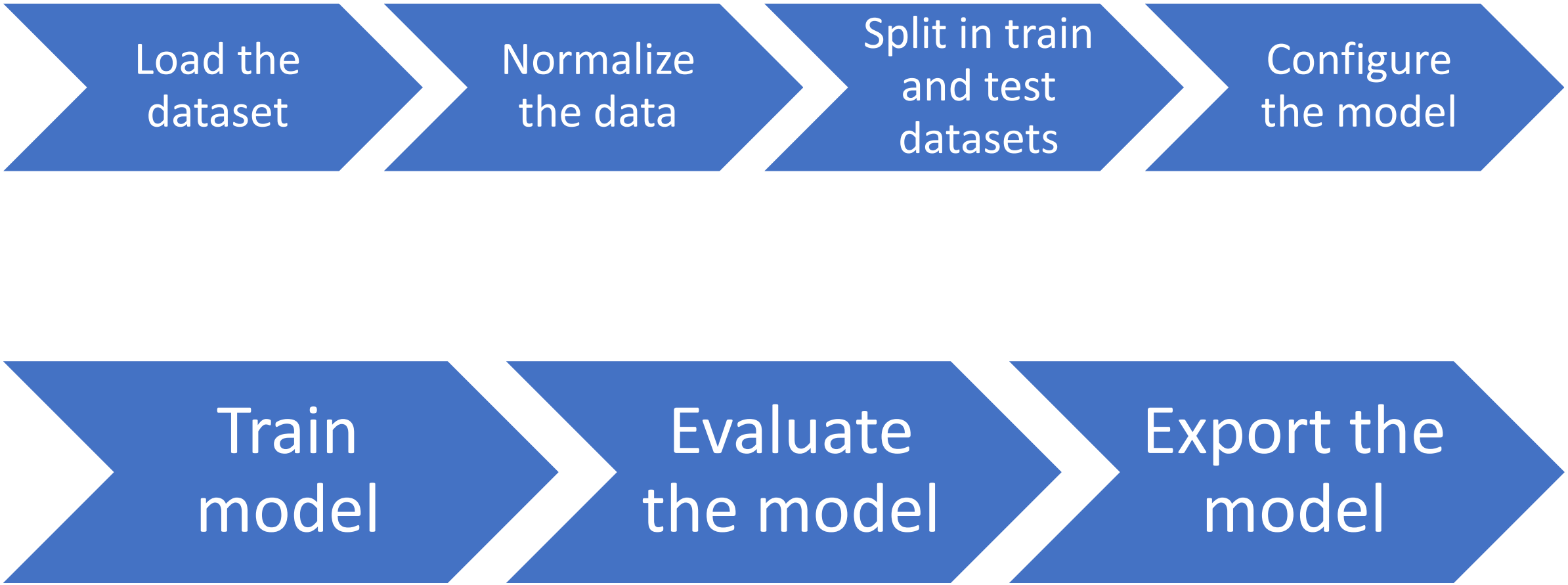
Problem description

- Type: Classification
- Dataset:
  - Number of instances: 150
  - Number of attributes: 4
    - sepal length in cm
    - sepal width in cm
    - petal length in cm
    - petal width in cm
  - Number of classes: 3
    - Iris Setosa
    - Iris Versicolour
    - Iris Virginica

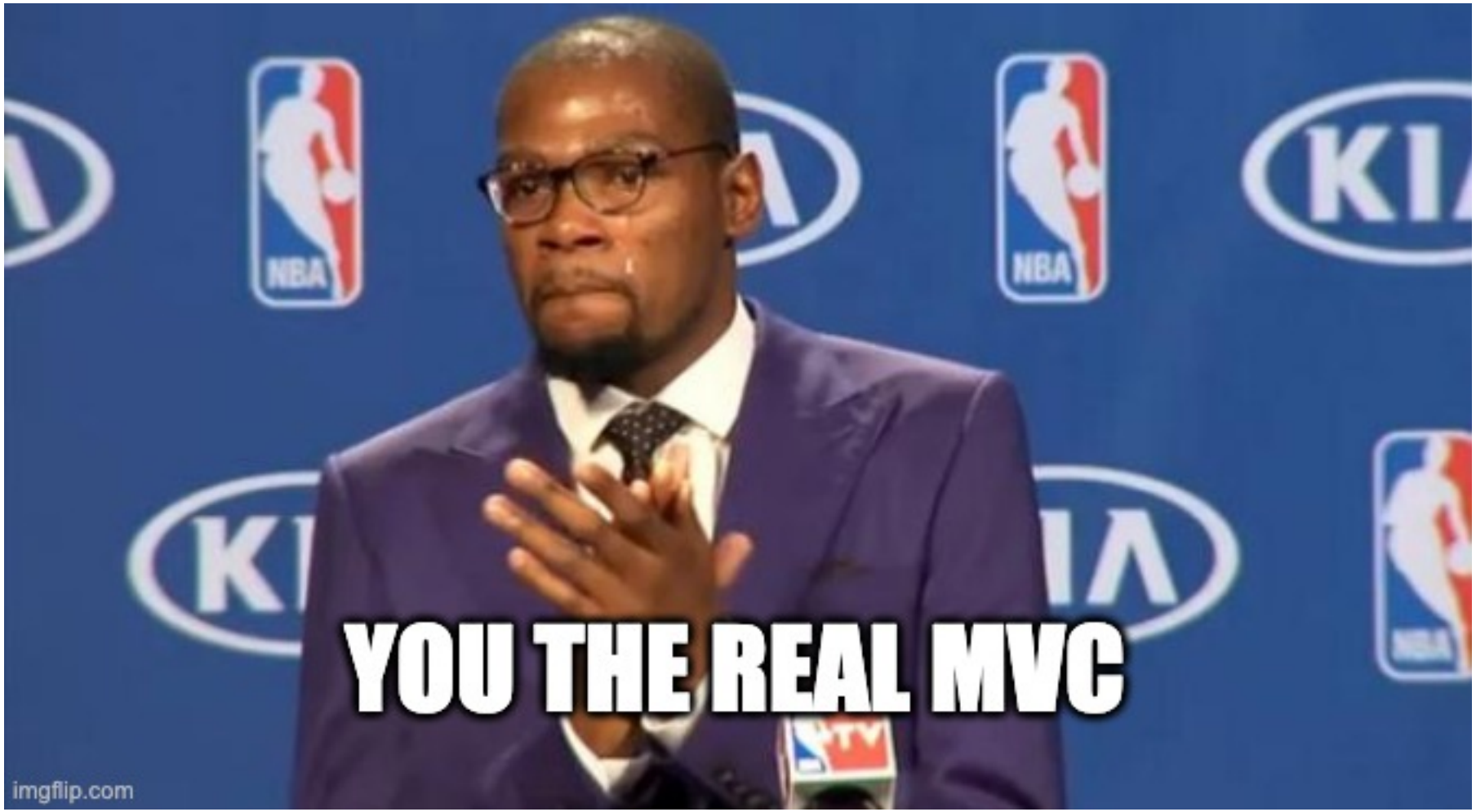
Source: University of California, Irvine , Iris Data Set. https://archive.ics.uci.edu/ml/datasets/iris , retrieved 08.2020


Labeled Dataset
Training step
DL4J
Prediction step
Data
fx
Prediction
=
Label

Training step



Iris Classifier Trainer Most Valuable Code



Load the dataset → Normalize the data → Split in train and test datasets → Configure the model → Train model → Evaluate the model → Export the model

```
private static DataSet loadData(String path) throws IOException, InterruptedException {
        DataSet allData;
        try (RecordReader recordReader = new CSVRecordReader(0, ',')) {
            recordReader.initialize(new FileSplit(new File(path)));
            DataSetIterator iterator = new RecordReaderDataSetIterator(
                                        recordReader, TOTAL_LINES, LABEL_INDEX, CLASSES_COUNT);
            allData = iterator.next();
        }
        return allData;
    }
```

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        }
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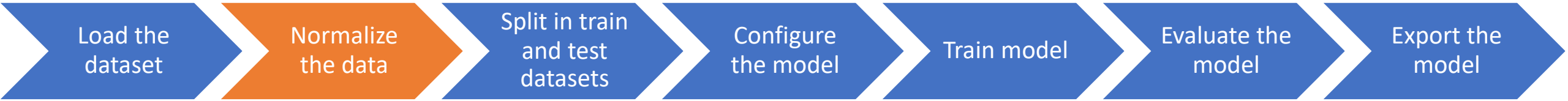
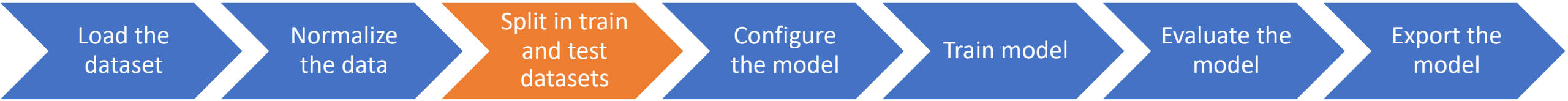
    }
```




```
// Normalize the data
DataNormalization normalizer = new NormalizerStandardize();
normalizer.fit(allData); // Get stats about the data
normalizer.transform(allData); // Transform the data by applying the normalization
```




```
// Split in train and test datasets
SplitTestAndTrain testAndTrain = allData.splitTestAndTrain(TRAIN_TO_TEST_RATIO); // 65%
DataSet trainingData = testAndTrain.getTrain();
DataSet testData = testAndTrain.getTest();
```

Load the dataset → Normalize the data → Split in train and test datasets → **Configure the model** → Train model → Evaluate the model → Export the model

```
private static MultiLayerConfiguration getMultiLayerConfiguration() {
    return new NeuralNetConfiguration.Builder()
            .seed(SEED)
            .activation(Activation.TANH)
            .weightInit(WeightInit.XAVIER)
            .updater(new Sgd(0.1))
            .l2(1e-4)
            .list()
            // The input layer must have FEATURES_COUNT = 4 nodes
            .layer(new DenseLayer.Builder().nIn(FEATURES_COUNT).nOut(3)
                    .build())
            .layer(new DenseLayer.Builder().nIn(3).nOut(3)
                    .build())
            .layer( new OutputLayer.Builder(LossFunctions.LossFunction.NEGATIVELOGLIKELIHOOD)
                    .activation(Activation.SOFTMAX)
                    .nIn(3)
                    // The output layer must have CLASSES_COUNT = 3 nodes
                    .nOut(CLASSES_COUNT).build())
            .build();
}
```

Load the dataset → Normalize the data → Split in train and test datasets → **Configure the model** → Train model → Evaluate the model → Export the model

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            .build();
}
```
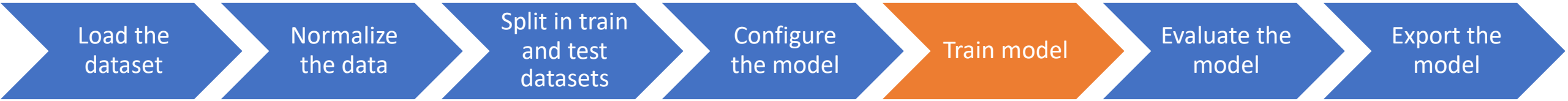

sepal length	sepal width	petal length	petal width
5,10	3,50	1,40	0,20

Types
Iris Setosa
Iris Virginica
Iris Versicolor

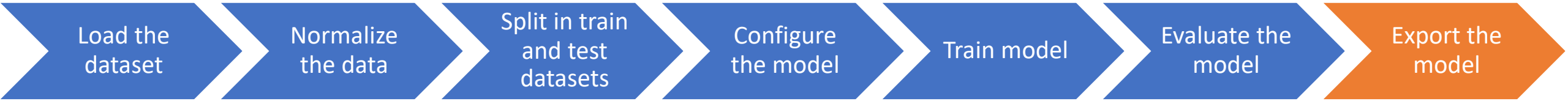



```
// Get configuration of the Neural Network
MultiLayerConfiguration configuration = getMultiLayerConfiguration();

// Train Neural Network
MultiLayerNetwork model = new MultiLayerNetwork(configuration);
model.init();
//Print score every 100 parameter updates
model.setListeners(new ScoreIterationListener(100));

// Do TRAIN_ITERATIONS = 1000 iterations to train the model
for(int x = 0; x < TRAIN_ITERATIONS; x++) {
    model.fit(trainingData);
}
```

Load the dataset → Normalize the data → Split in train and test datasets → Configure the model → Train model → **Evaluate the model** → Export the model

```
private static Evaluation evaluate(MultiLayerNetwork model,
                                   DataSet testData) {
    INDArray output = model.output(testData.getFeatures());
    Evaluation eval = new Evaluation(CLASSES_COUNT); // 4 Classes
    eval.eval(testData.getLabels(), output);
    return eval;
}
```

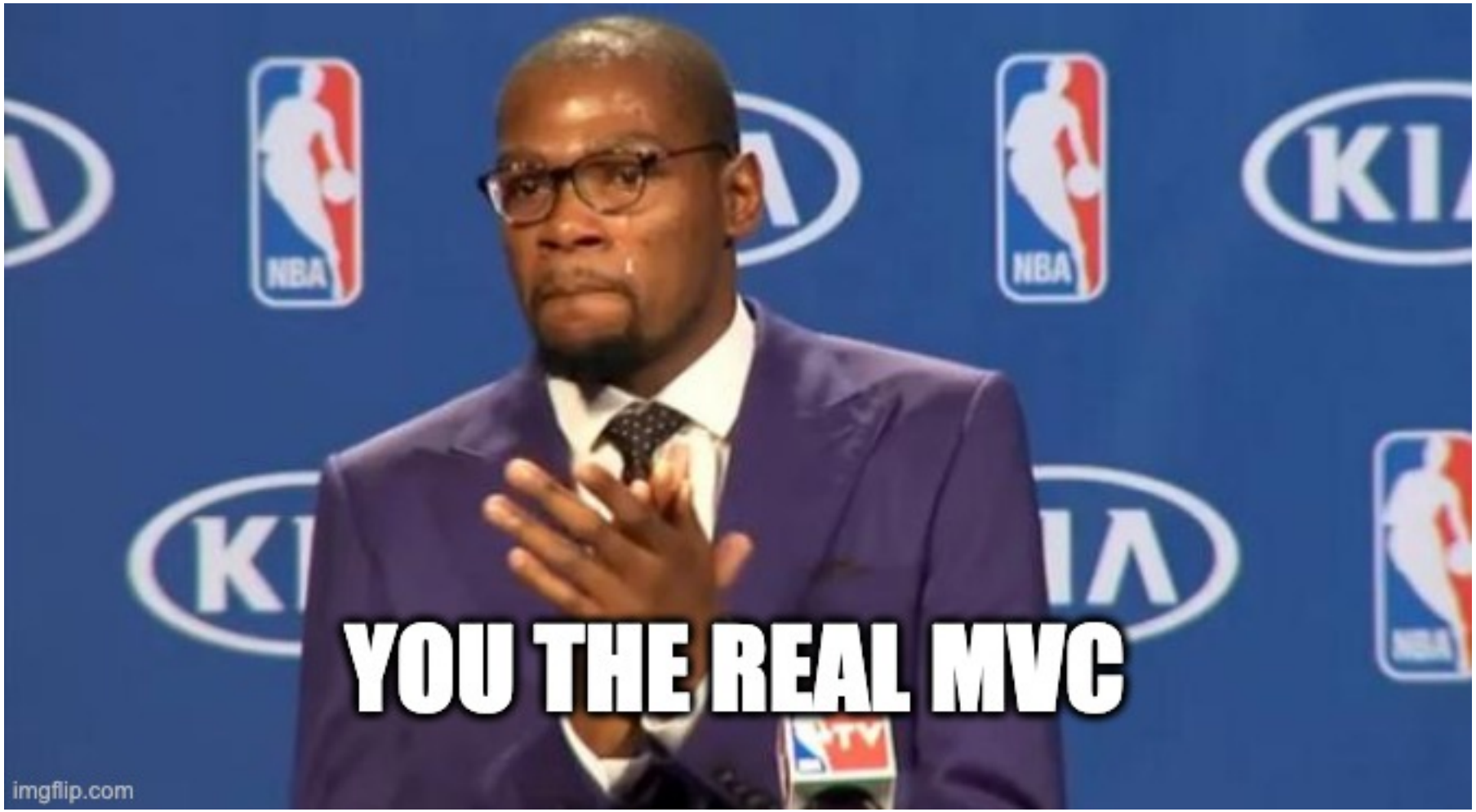
```
=======================Evaluation Metrics=======================
 # of classes:    3
 Accuracy:        0.9245
 Precision:       0.9206
 Recall:          0.9167
 F1 Score:        0.9163
Precision, recall & F1: macro-averaged (equally weighted avg. of 3 classes)


=========================Confusion Matrix=========================
  0  1  2
----------
 21  0  0 | 0 = 0
  0 15  1 | 1 = 1
  0  3 13 | 2 = 2

Confusion matrix format: Actual (rowClass) predicted as (columnClass) N times
==================================================================
```




```
// Storing the model
File locationToSaveModel = new File(outputPath + STORED_MODEL_FILENAME);
model.save(locationToSaveModel, false);

// Storing the normalizer
File locationToSaveNormalizer = new File(outputPath + STORED_NORMALIZER_FILENAME);
NormalizerSerializer.getDefault().write(normalizer, locationToSaveNormalizer);
```

Prediction step

Iris Classifier Predictor Most Valuable Code



Load the model → Format the data → Normalize the data → Feed the data → Get the label

```
// Load the model
File locationToSaveModel = new File(basePath + STORED_MODEL_FILENAME);
MultiLayerNetwork restoredModel = MultiLayerNetwork.load(locationToSaveModel, false);

// Load normalizer
File locationToSaveNormalizer = new File(basePath + STORED_NORMALIZER_FILENAME);
DataNormalization restoredNormalizer = normalizerSerializer.getDefault()
                                                .restore(locationToSaveNormalizer);
```

Load the model → Format the data → Normalize the data → Feed the data → Get the label

```
private static INDArray getArray(Iris iris) {
    float[] input = new float[FIELDS_COUNT];
    input[INDEX_SEPAL_LENGTH] = iris.getSepalLength();
    input[INDEX_SEPAL_WIDTH] = iris.getSepalWidth();
    input[INDEX_PETAL_LENGTH] = iris.getPetalLength();
    input[INDEX_PETAL_WIDTH] = iris.getPetalWidth();

    DataBuffer dataBuffer = new FloatBuffer(input);
    NDArray ndArray = new NDArray(1, FIELDS_COUNT);
    ndArray.setData(dataBuffer);
    return ndArray;
}
```

Load the model → Format the data → Normalize the data → Feed the data → Get the label

```
// Normalize the data the same way it was normalized in the training phase
dataNormalizer.transform(indArray);

// Do the prediction
INDArray result = model.output(indArray, false);
```

Load the model → Format the data → Normalize the data → Feed the data → Get the label

```
private static int getIndexPredictedLabel(INDArray predictions) {
        int maxIndex = 0;
        // We should get max CLASSES_COUNT amount of predictions with probabilities.
        for (int i = 0; i < CLASSES_COUNT; i++) {
            if (predictions.getFloat(i) > predictions.getFloat(maxIndex)) {
                maxIndex = i;
            }
        }
        return maxIndex;
    }
```


```
List<String> LABELS = Arrays.asList("Iris Setosa",
                                    "Iris Versicolour",
                                    "Iris Virginica");
int predictedLabelIndex = getIndexPredictedLabel(result);
return LABELS.get(predictedLabelIndex);
```

Prediction step

sepal length	sepal width	petal length	petal width
5,10	3,50	1,40	0,20

FlowerClassification API

Iris Setosa

Peter is happy!

What did we learn?

- 2 main steps
  - Training
    - Input: Labeled dataset
    - Output: Trained model
  - Prediction
    - Input: Trained model + unlabeled data
    - Output: Prediction -> in this case, of type “classification”

- How to use Deeplearning4j to train a model, export it, load it and perform a prediction

Machine Learning Approaches

- Supervised
  - Classification
  - Regression
- Unsupervised
- Reinforcement learning

Source: Wikipedia, Machine Learning. https://en.wikipedia.org/wiki/Machine_learning , retrieved 08.2020

Machine Learning Approaches

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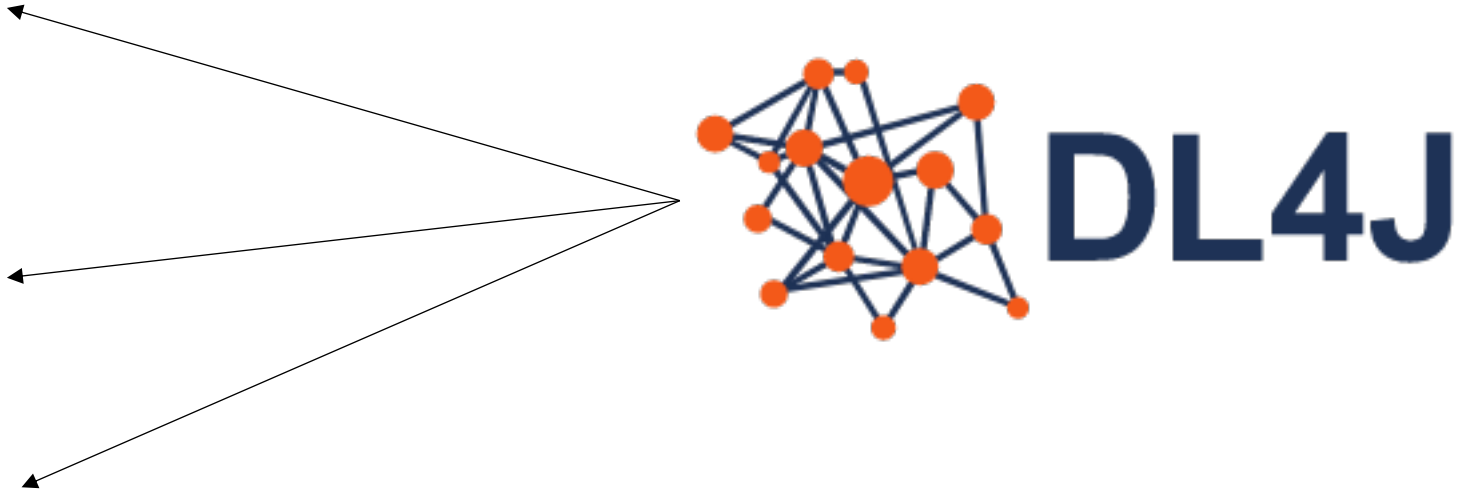


Machine Learning Algorithms

- Examples:
  - Support Vector Machines
  - Linear regression
  - Logistic regression
  - Naive Bayes
  - Linear discriminant analysis
  - Decision trees
  - Neural Networks (Multilayer perceptron)
  - …

Source: Wikipedia, Machine Learning. https://en.wikipedia.org/wiki/Machine_learning , retrieved 08.2020

Deeplearning4j integrations

Distributed training

Images sources
Apache Spark logo, https://spark.apache.org/images/spark-logo-trademark.png
Apache Hadoop logo, https://hadoop.apache.org/hadoop-logo.jpg

Deeplearning4j integrations

Parallel training

Import models

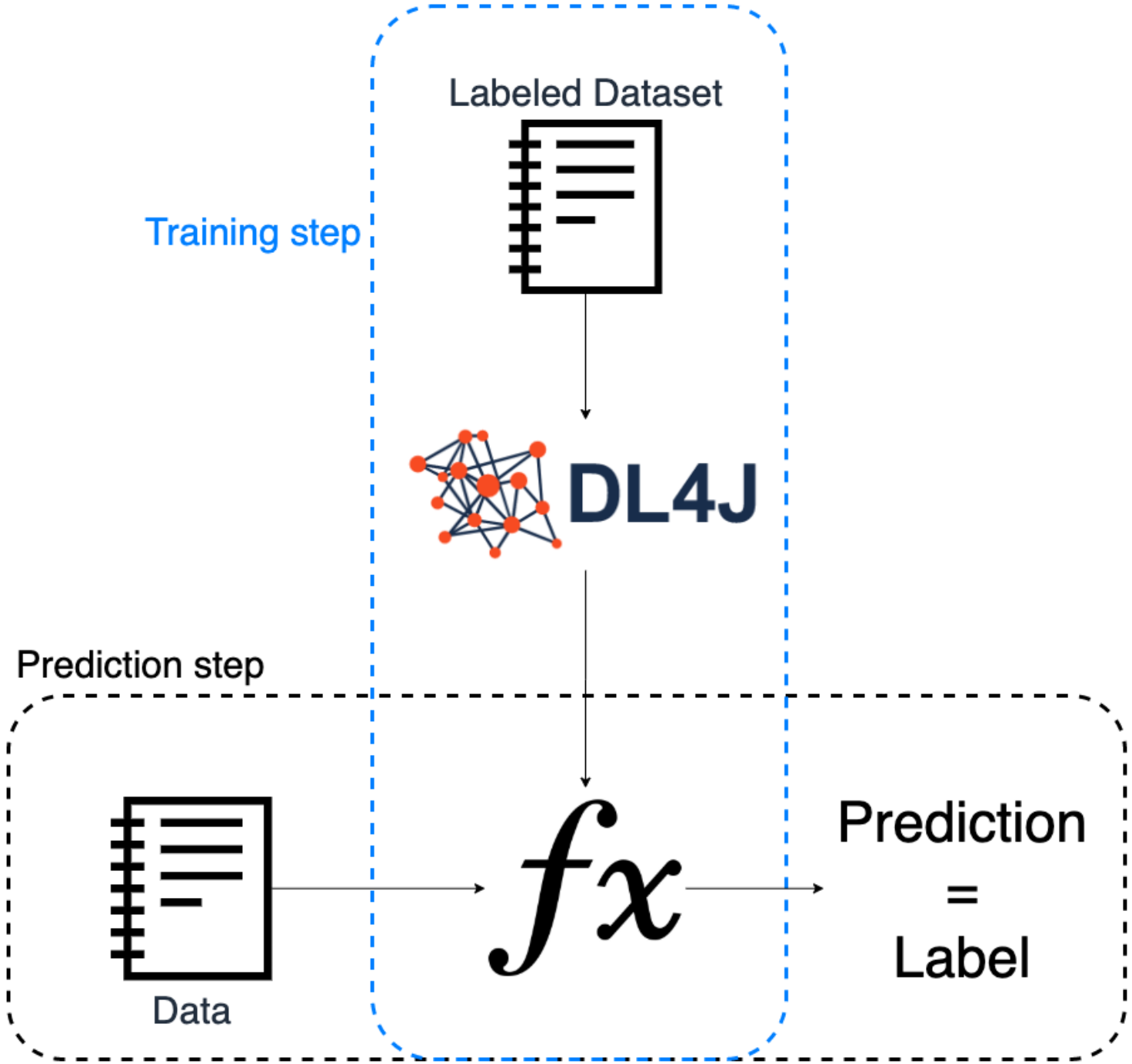
Images source:
Keras logo, https://keras.io/img/logo.png
Nivida CUDA logo, https://en.wikipedia.org/w/index.php?curid=53650345

Deeplearning4j integrations

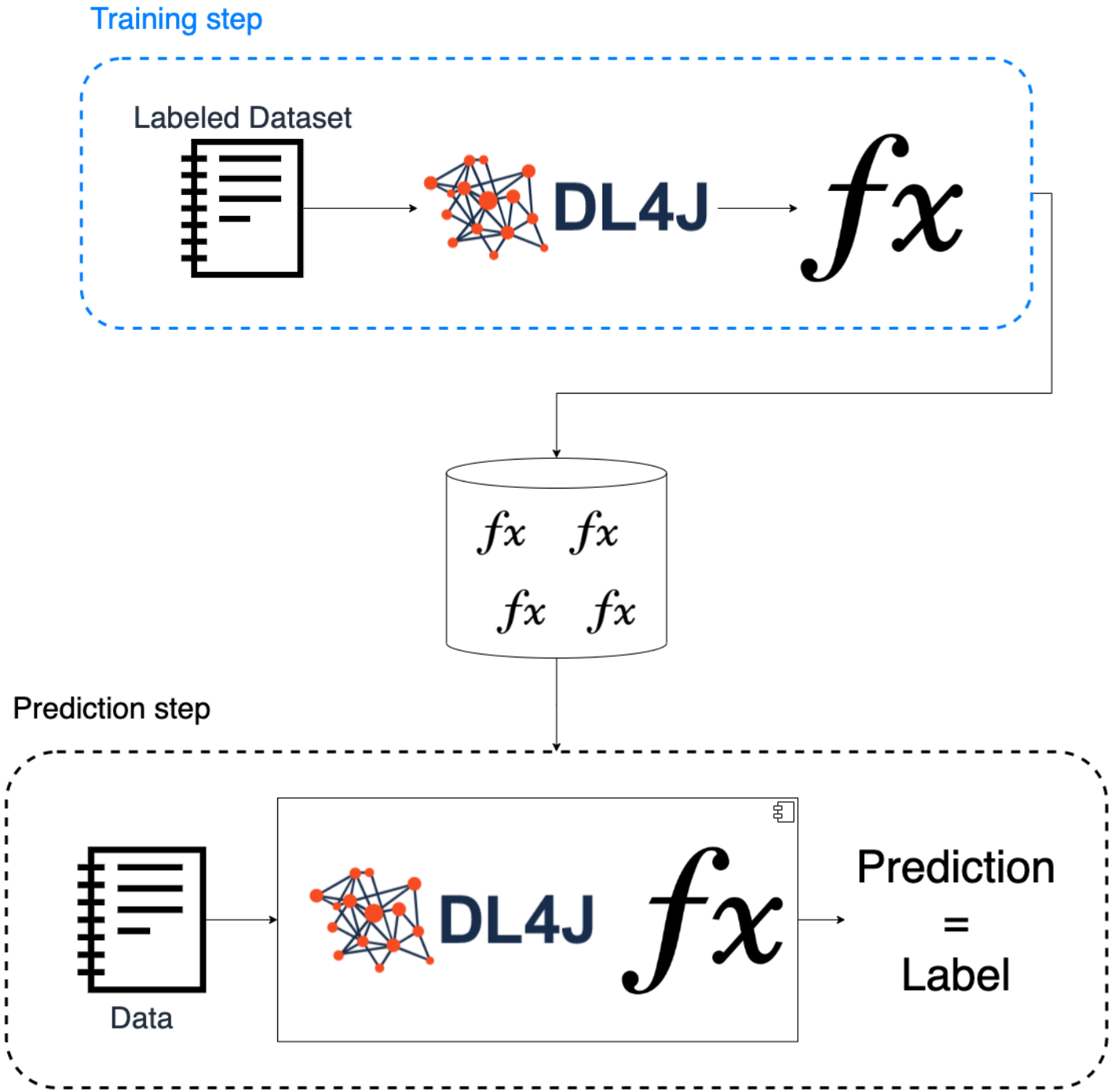
Keras is an open-source neural-network library written in Python. It is capable of running on top of TensorFlow, Microsoft Cognitive Toolkit, R, Theano, or PlaidML.

source:
Keras logo, https://keras.io/img/logo.png
Keras description, Keras, https://en.wikipedia.org/wiki/Keras , retrieved 08/2020

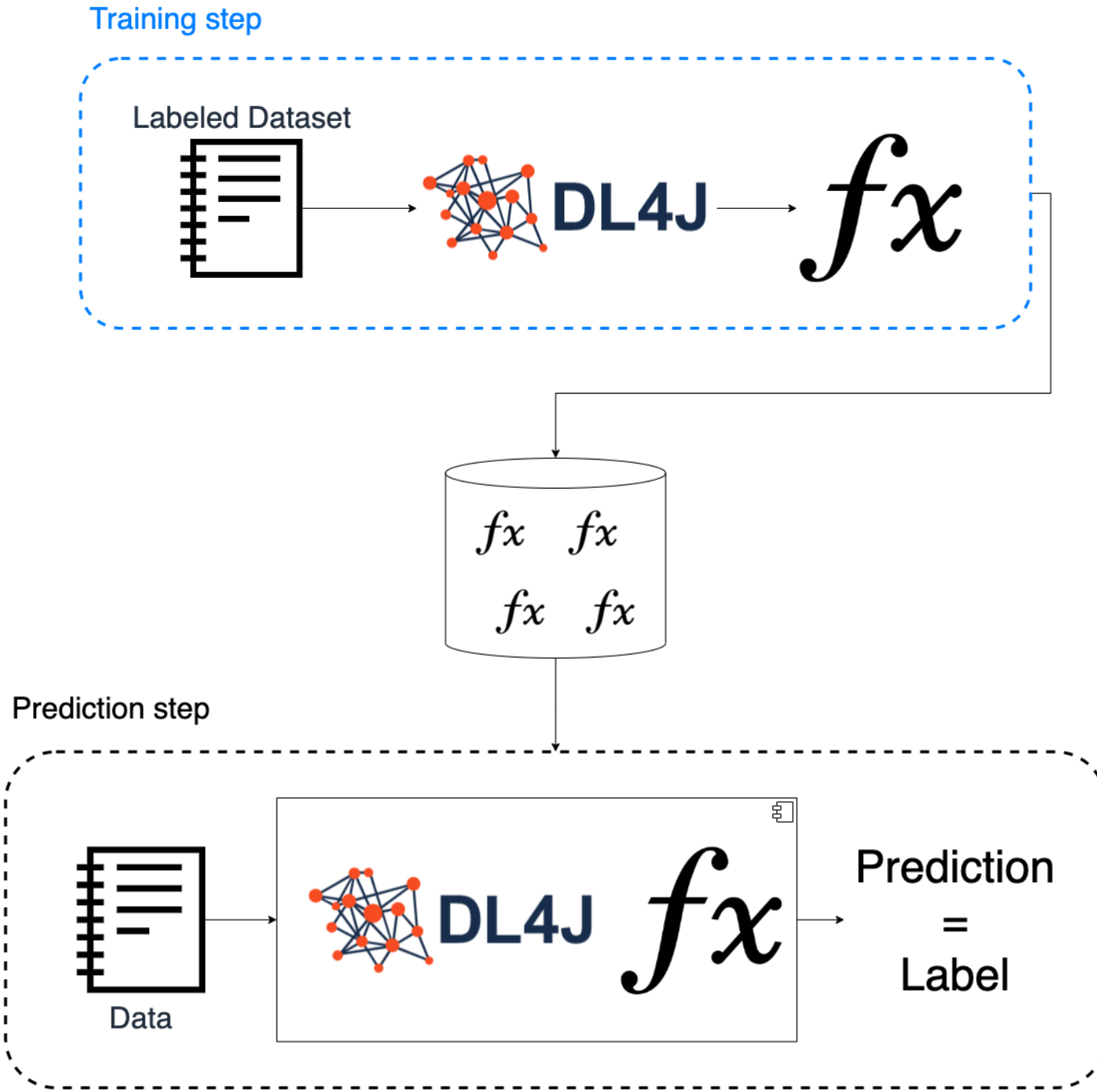
One step back



Decoupled in time!



* JVM Language



DL4J + Keras

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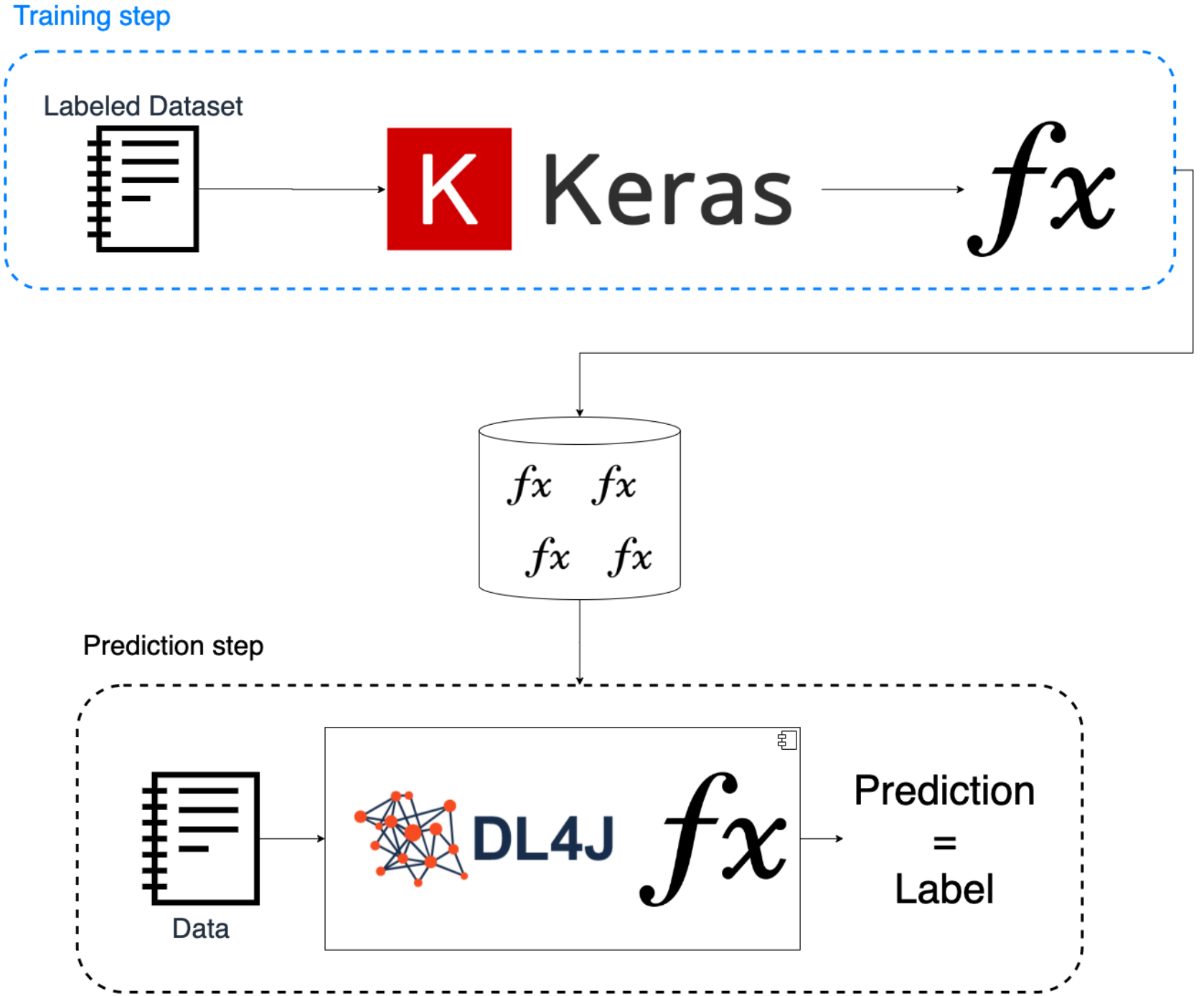
Flexibility

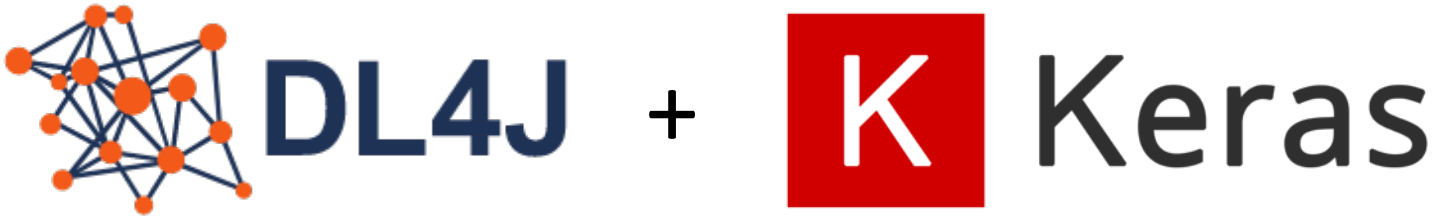

python


Java


Training step
Labeled Dataset
Keras
fx
fx fx
fx fx
Prediction step
Data
DL4J
fx
Prediction
=
Label

Deeplearning4j integrations

- Enables the integration of people with different technical profiles
- Opens the door to more pretrained models



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Flexibility

Image Classification

- Approach:
  - Deeplearning4j’s Model Zoo
  - OpenCV

Deeplearning4j's Model Zoo

master — deeplearning4j / deeplearning4j / deeplearning4j-zoo / src / main / java / org / deeplearning4j / zoo / **model** /

AlexDBlack Refactor packages to fix split package issues (#411) ...

..	
helper	Refactor packages to fix split package issues (#411)
AlexNet.java	Fixing issues from Sonar report (#391)
Darknet19.java	Eclipse Migration Initial Commit
FaceNetNN4Small2.java	Eclipse Migration Initial Commit
InceptionResNetV1.java	Eclipse Migration Initial Commit
LeNet.java	Eclipse Migration Initial Commit
NASNet.java	Refactor packages to fix split package issues (#411)
ResNet50.java	Eclipse Migration Initial Commit
SimpleCNN.java	Eclipse Migration Initial Commit
SqueezeNet.java	Eclipse Migration Initial Commit
TextGenerationLSTM.java	Eclipse Migration Initial Commit
TinyYOLO.java	Eclipse Migration Initial Commit
UNet.java	Various SameDiff fixes (#21)
VGG16.java	Eclipse Migration Initial Commit
VGG19.java	Eclipse Migration Initial Commit
Xception.java	Eclipse Migration Initial Commit
YOLO2.java	Eclipse Migration Initial Commit

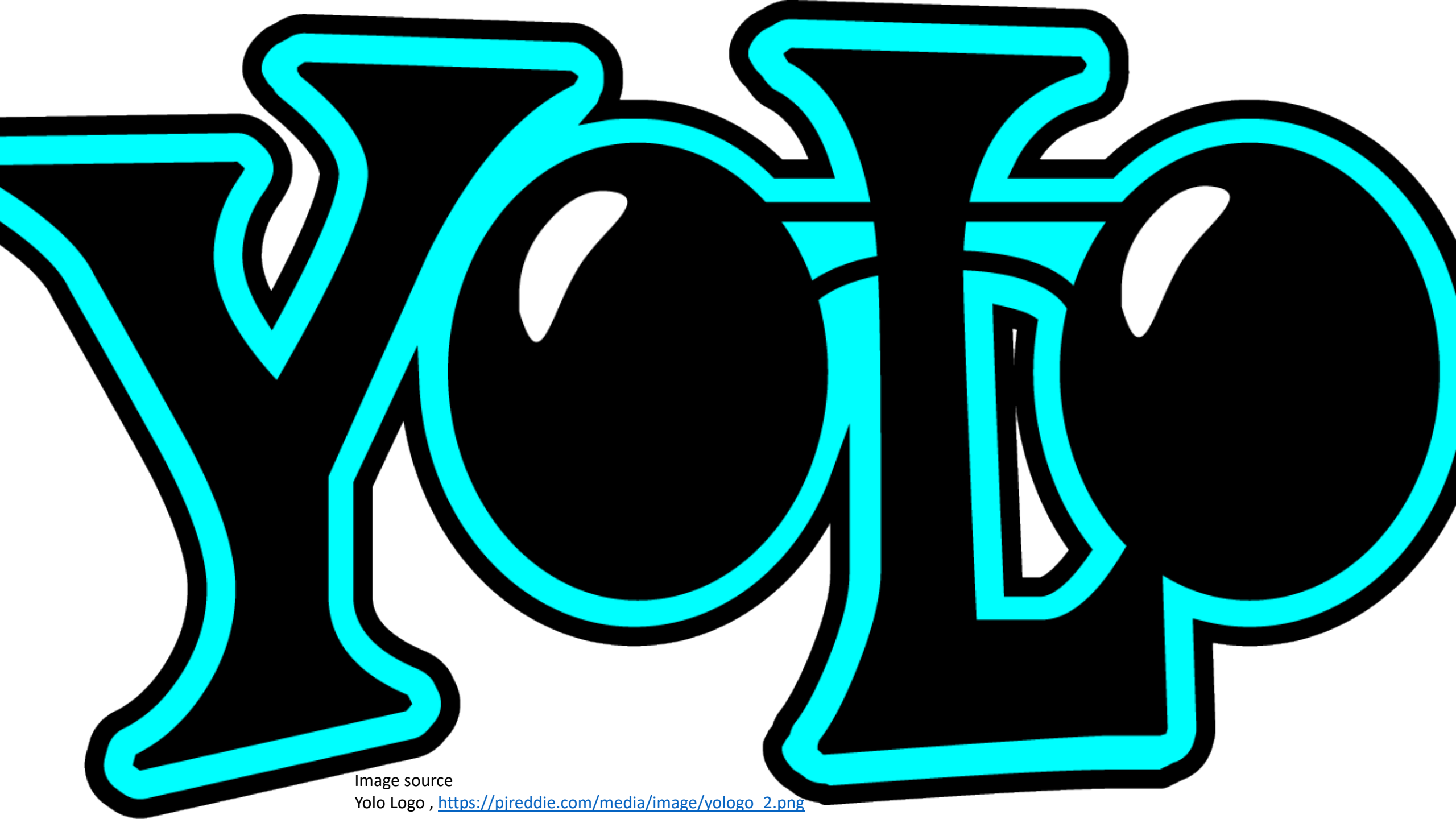


Image source
Yolo Logo , https://pjreddie.com/media/image/yologo_2.png

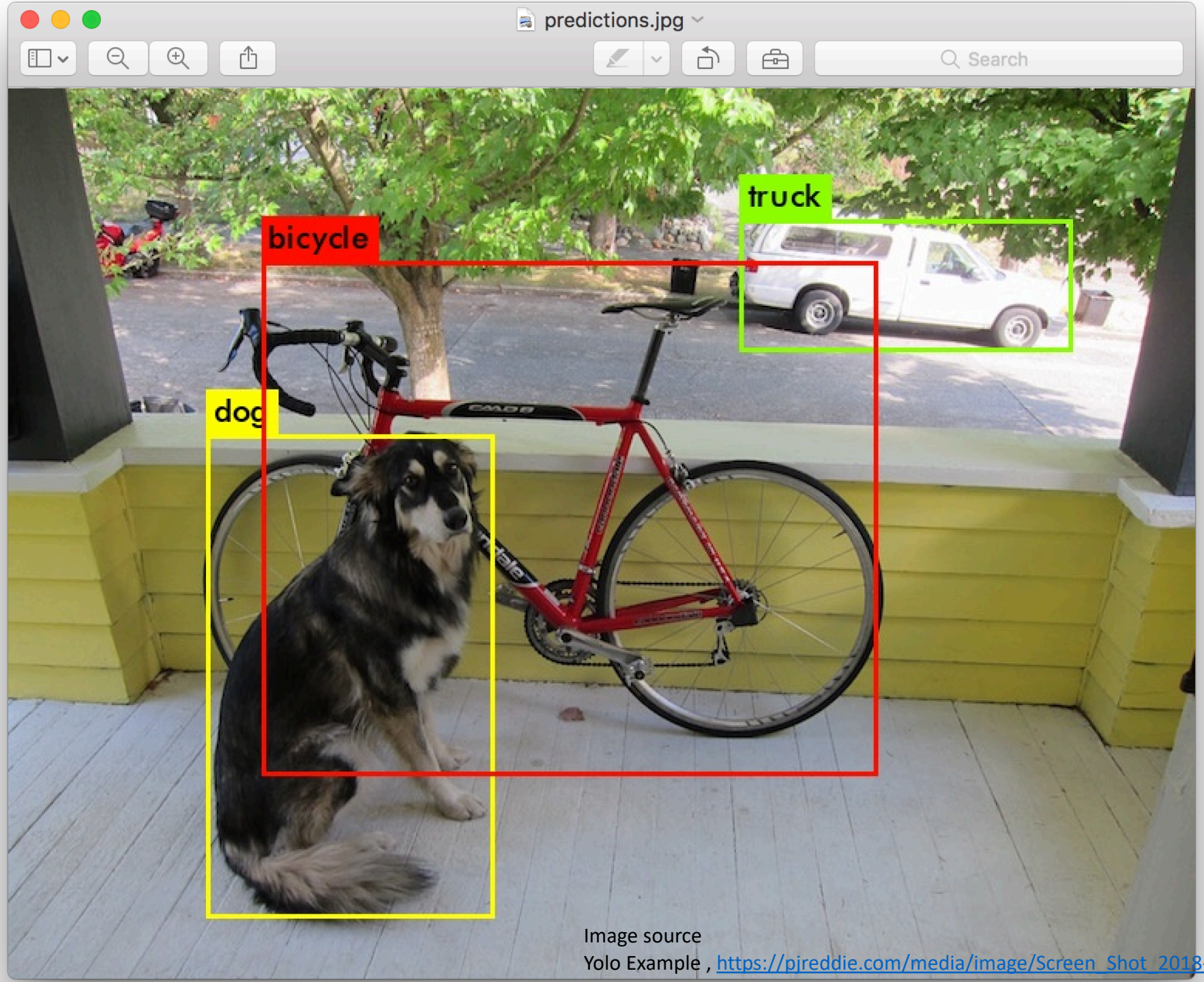


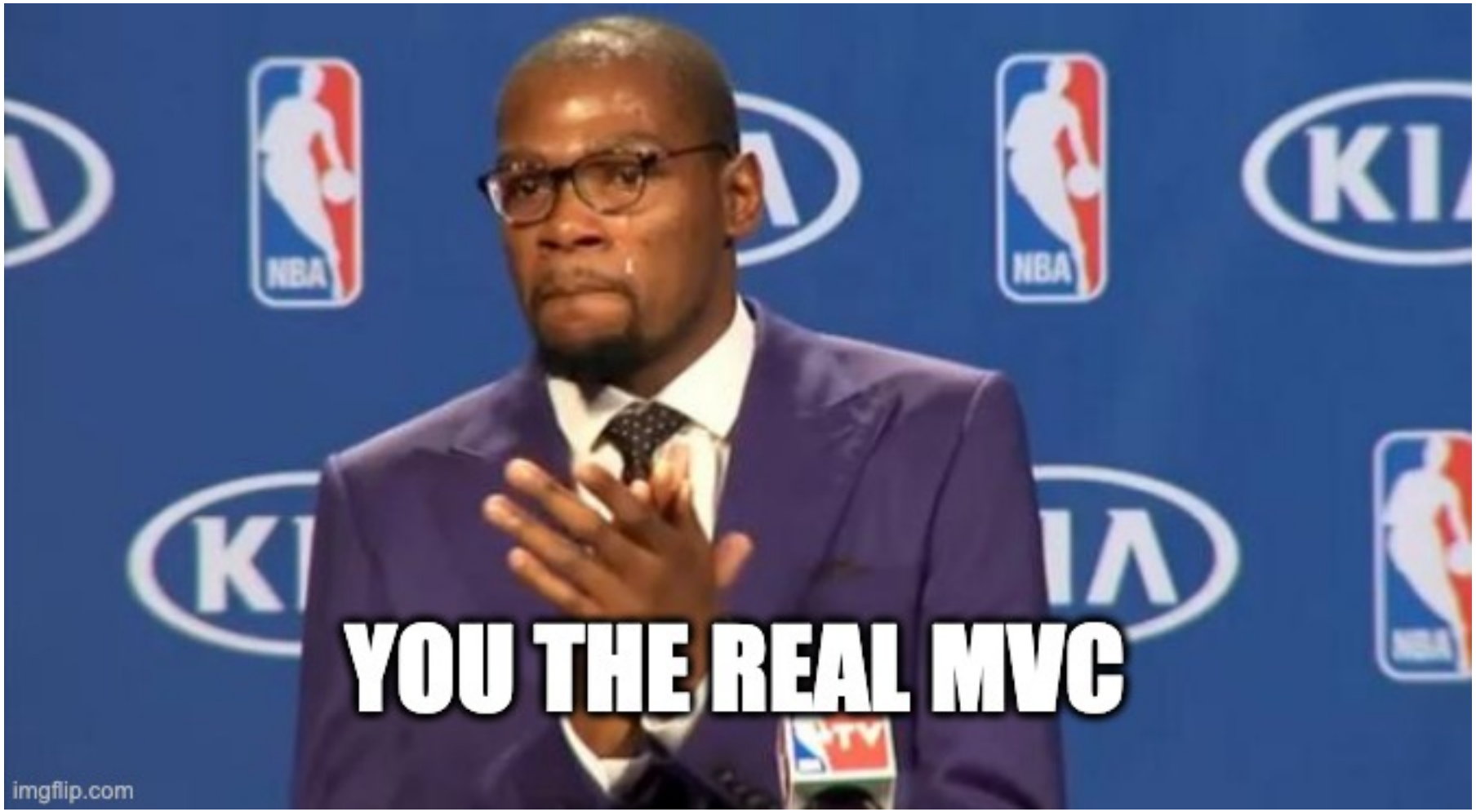
Image source
Yolo Example , https://pjreddie.com/media/image/Screen_Shot_2018-03-24_at_10.48.42_PM.png

YOLOv2 Available Labels

person	fire hydrant	elephant	skis	wine glass	broccoli	diningtable	toaster
bicycle	stop sign	bear	snowboard	cup	carrot	toilet	sink
car	parking meter	zebra	sports ball	fork	hot dog	tvmonitor	refrigerator
motorbike	bench	giraffe	kite	knife	pizza	laptop	book
aeroplane	bird	backpack	baseball bat	spoon	donut	mouse	clock
bus	cat	umbrella	baseball glove	bowl	cake	remote	vase
train	dog	handbag	skateboard	banana	chair	keyboard	scissors
truck	horse	tie	surfboard	apple	sofa	cell phone	teddy bear
boat	sheep	suitcase	tennis racket	sandwich	pottedplant	microwave	hair drier
traffic light	cow	frisbee	bottle	orange	bed	oven	toothbrush

Steps overview

Yolo2ImageClassifier - Most Valuable Code



```java
public List<DetectedObject> classify(String inputImagePath, String outputImagePath) throws IOException {
    // Load the model from zoo
    yolo2Model = YOLO2.builder().build();
    pretrainedComputationGraph = (ComputationGraph) yolo2Model.initPretrained();

    // Load the image from disk
    File fileOriginalImage = new File(inputImagePath);
    INDArray iNDArrayImage = imageLoader.asMatrix(fileOriginalImage);

    // Resize the image to match the required size by YOLO2
    Mat matRawImage = yoloImageLoader.asMat(iNDArrayImage);
    Mat resizeImage = new Mat();
    resize(matRawImage, resizeImage, new Size(YOLO2_WIDTH, YOLO2_HEIGHT));

    // Scale the images, as in "normalize the pixels to be on the range from 0 to 1"
    ImagePreProcessingScaler scaler = new ImagePreProcessingScaler(0, 1);
    INDArray inputImage = yoloImageLoader.asMatrix(resizeImage);
    scaler.transform(inputImage);

    // Perform the classification
    INDArray outputs = pretrainedComputationGraph.outputSingle(inputImage);
    List<DetectedObject> detectedObjects = YoloUtils.getPredictedObjects
            (Nd4j.create(((YOLO2) yolo2Model).getPriorBoxes()),
                    outputs,
                    DETECTION_THRESHOLD,
                    NMS_THRESHOLD);

    // Annotate the original image
    Image originalImage = imageLoader.asImageMatrix(fileOriginalImage);
    int originalWidth = originalImage.getOrigW();
    int originalHeight = originalImage.getOrigH();
    annotate(originalWidth, originalHeight, matRawImage, detectedObjects, outputImagePath);

   return detectedObjects;
}
```

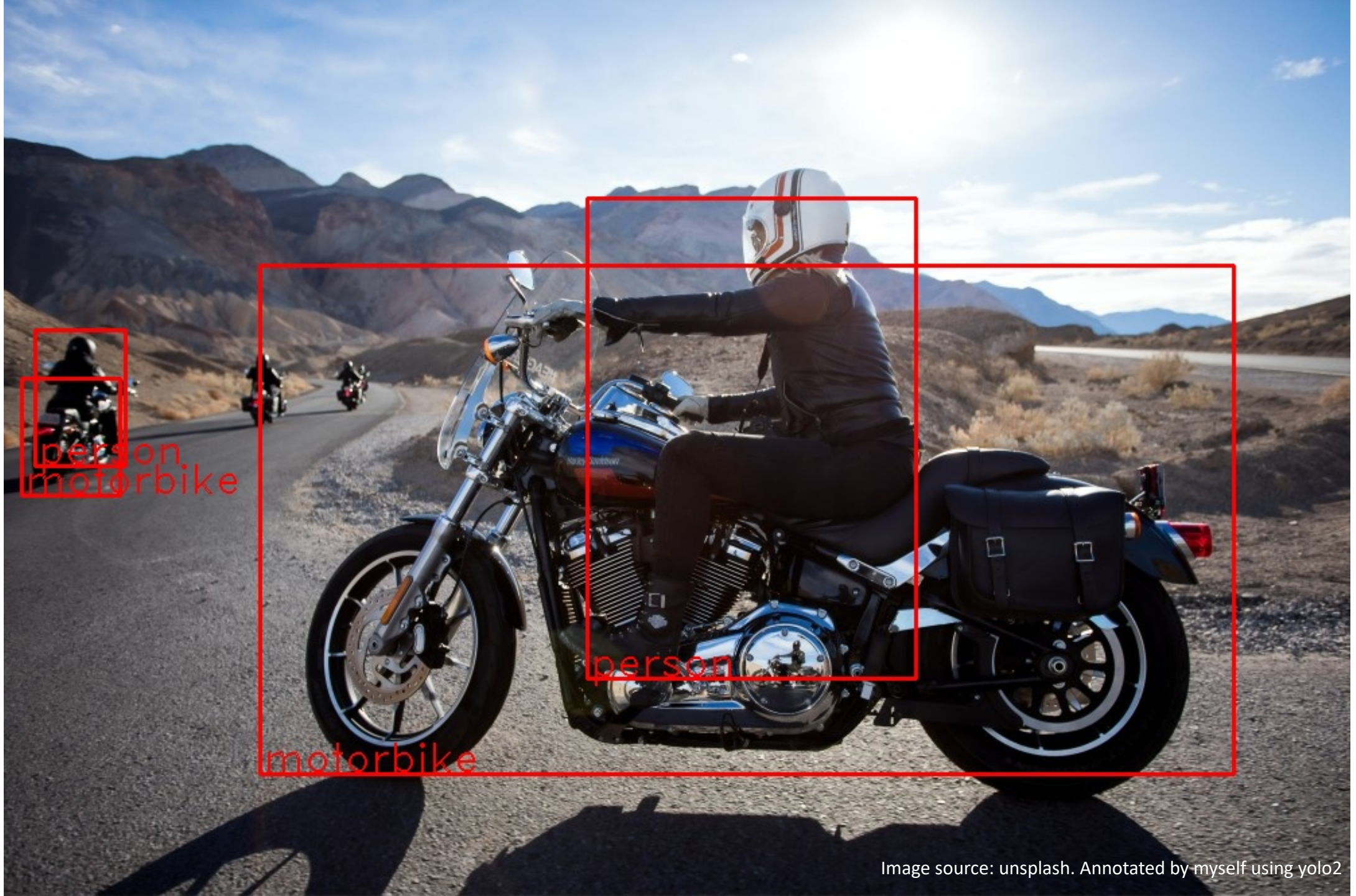


Image source: unsplash. Annotated by myself using yolo2

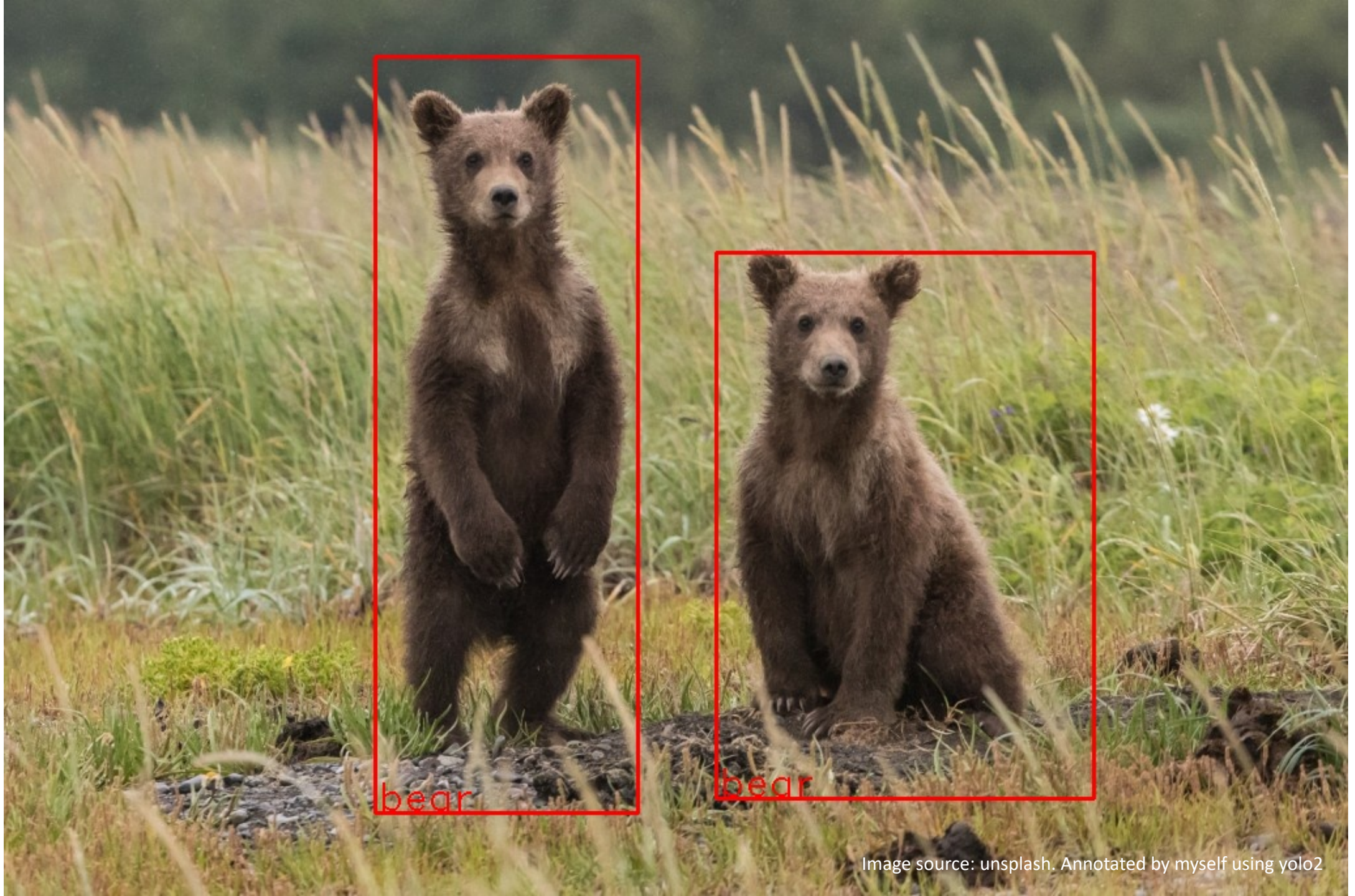


Image source: unsplash. Annotated by myself using yolo2

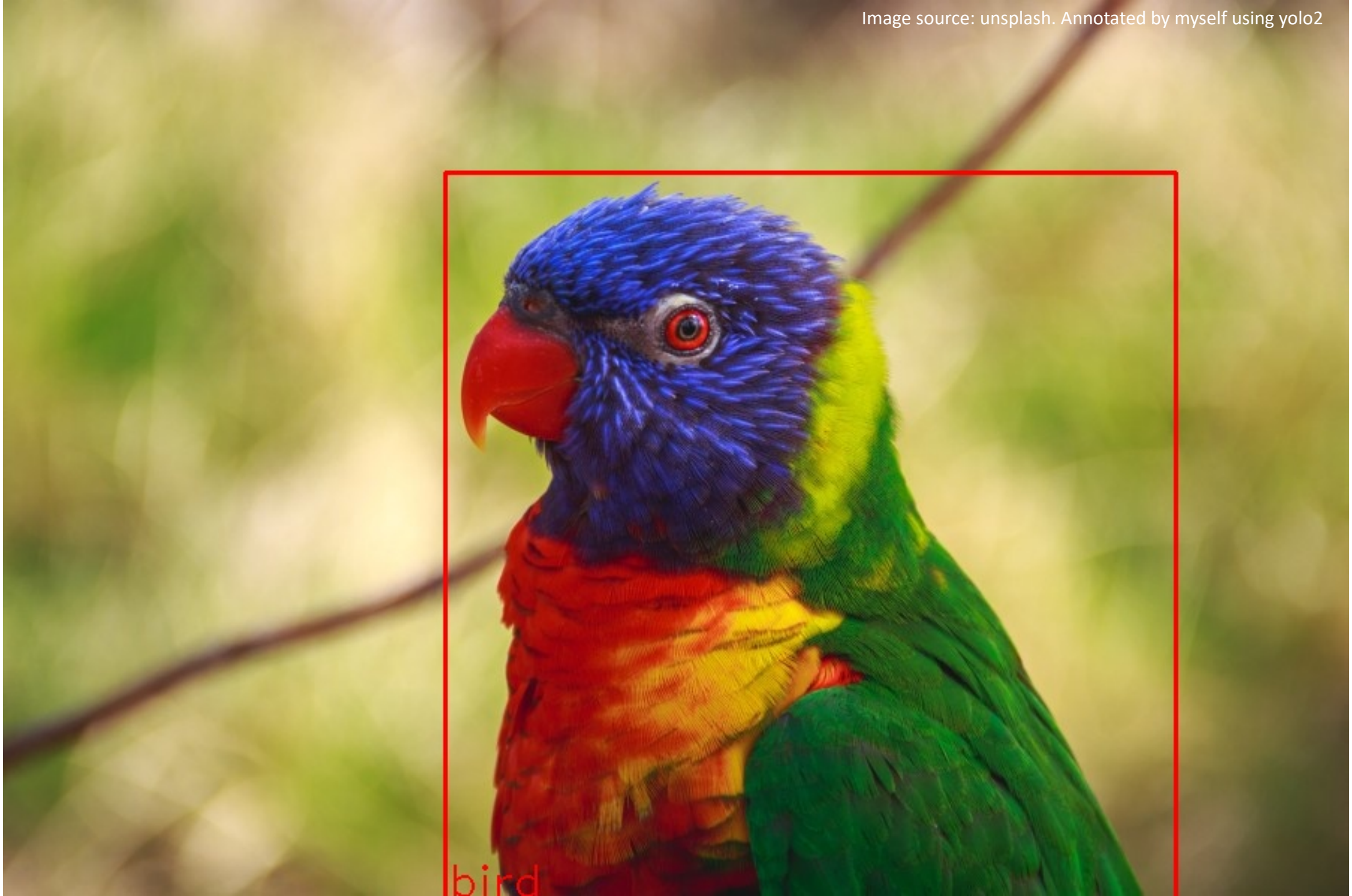


Image source: unsplash. Annotated by myself using yolo2

Image source: unsplash. Annotated by myself using yolo2

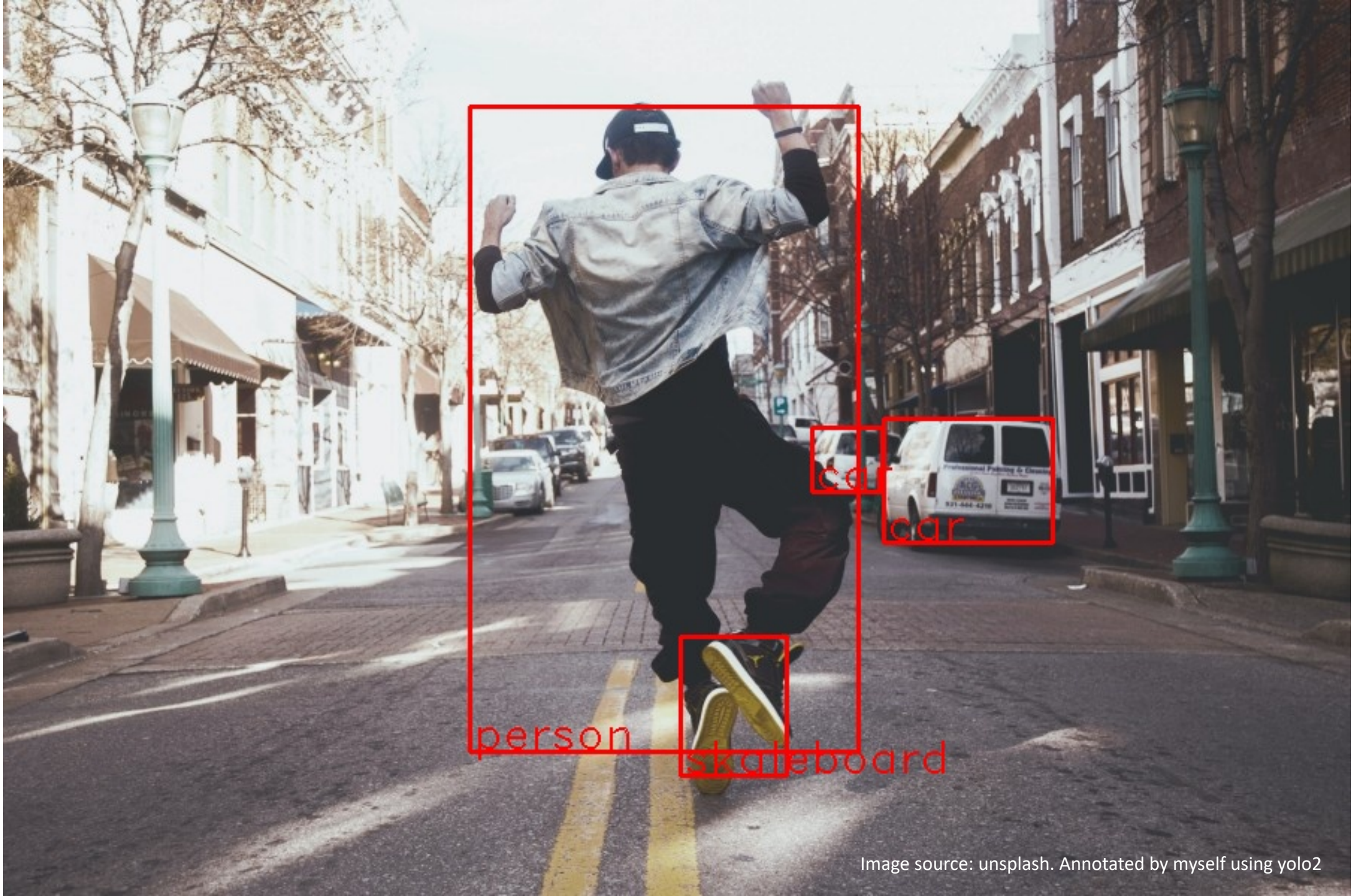


Image source: unsplash. Annotated by myself using yolo2

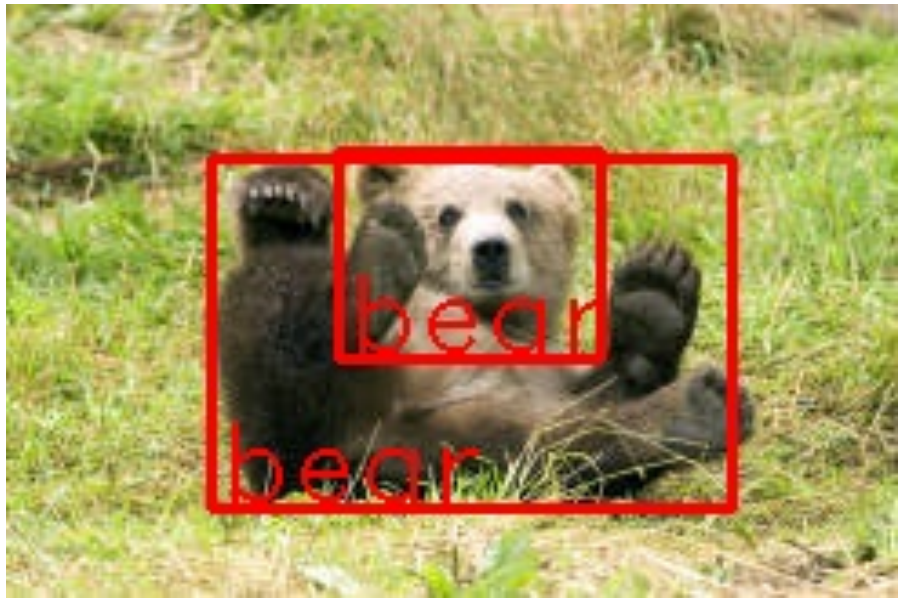


Image source: Deeplearning4j Animal Classification Dataset. Annotated by myself using yolo2

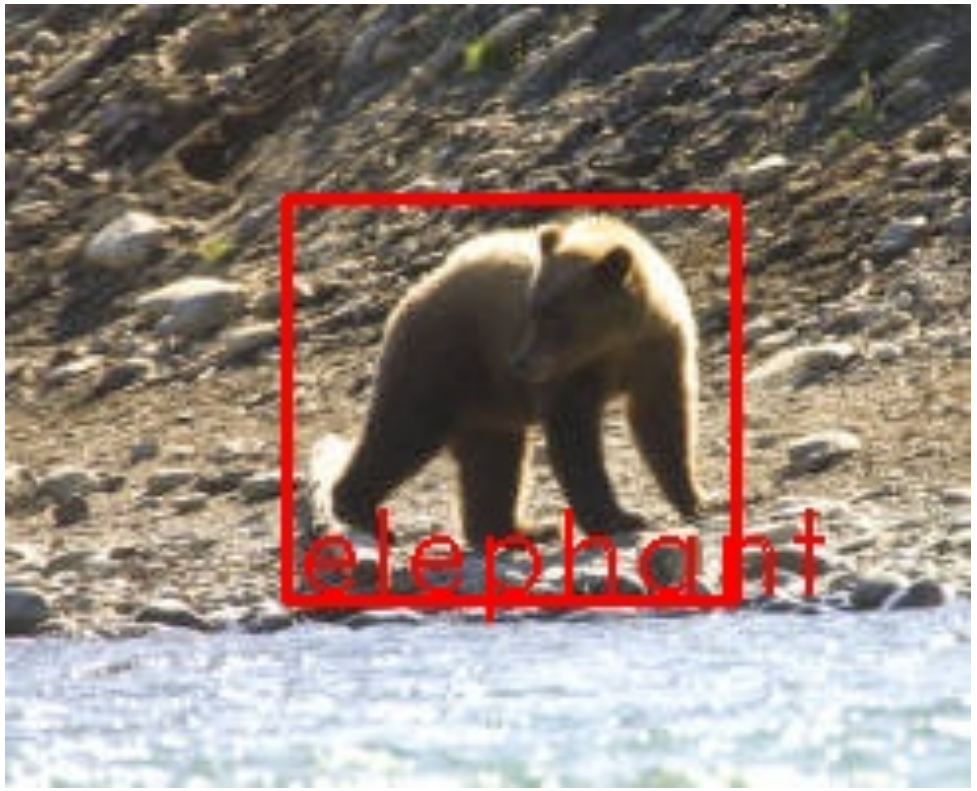


Image source: Deeplearning4j Animal Classification Dataset. Annotated by myself using yolo2

Sentiment Analysis

- Approach:
  - Take an example and modify it
    - deeplearning4j.examples - ImdbReviewClassificationCNN.java
  - Get a new dataset from https://www.kaggle.com/kazanova/sentiment140

Dataset

781

Sentiment140 dataset with 1.6 million tweets

Sentiment analysis with tweets

Μαριος Μιχαηλιδης KazAnova • updated 3 years ago (Version 2)

Usability 8.8 **License** Other (specified in description) **Tags** internet, online communities, social networks, linguistics, languages

Description

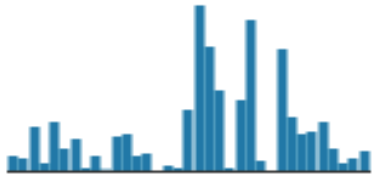
Context

This is the sentiment140 dataset. It contains 1,600,000 tweets extracted using the twitter api . The tweets have been annotated (0 = negative, 4 = positive) and they can be used to detect sentiment .

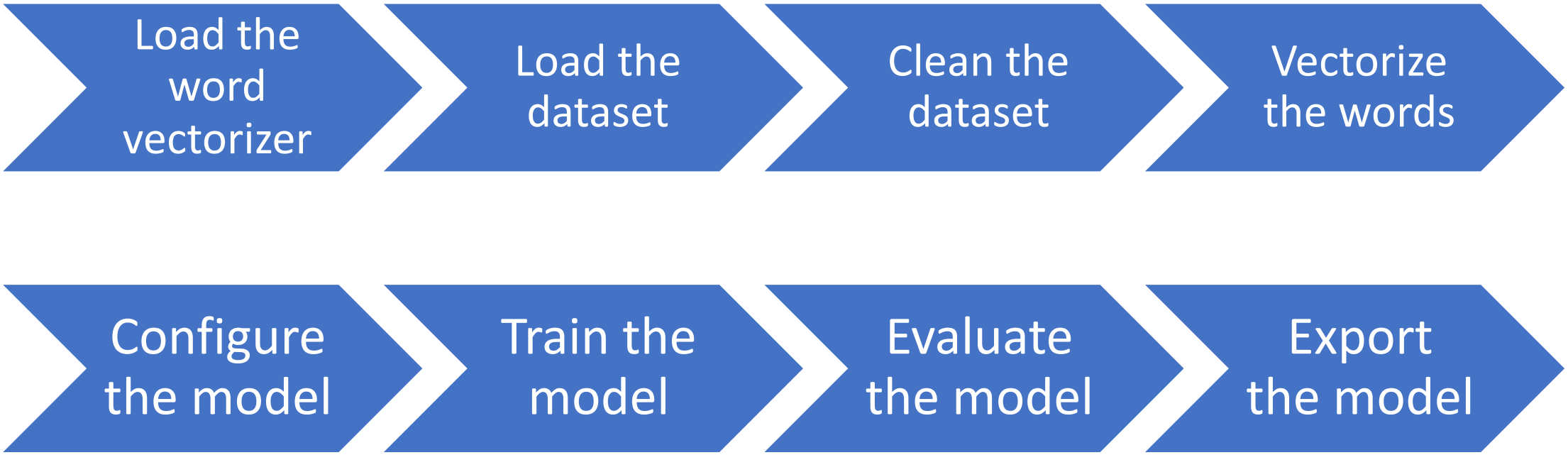
Content

It contains the following 6 fields:

1. target: the polarity of the tweet (*0* = negative, *2* = neutral, *4* = positive)

# 0	# 1467810369	A Mon Apr 06 22:1...	A NO_QUERY	A _TheSpecialOne_	A @switchfoot htt...
target	id	date	flag	user	text
 0 4	 1.47b 2.33b	774362 unique values	1 unique value	659775 unique values	1581465 unique values
0	1467810672	Mon Apr 06 22:19:49 PDT 2009	NO_QUERY	scotthamilton	is upset that he can't update his Facebook by texting it... and might cry as a result School today ...
0	1467810917	Mon Apr 06 22:19:53 PDT 2009	NO_QUERY	mattycus	@Kenichan I dived many times for the ball. Managed to save 50% The rest go out of bounds
0	1467811184	Mon Apr 06 22:19:57 PDT 2009	NO_QUERY	ElleCTF	my whole body feels itchy and like its on fire
0	1467811193	Mon Apr 06 22:19:57 PDT 2009	NO_QUERY	Karoli	@nationwideclass no, it's not behaving at all. i'm mad. why am i here? because I can't see you all o...
0	1467811372	Mon Apr 06 22:20:00	NO_QUERY	joy_wolf	@Kwesidei not the

Overview


Load the word vectorizer
Load the dataset
Clean the dataset
Vectorize the words
Configure the model
Train the model
Evaluate the model
Export the model

Vectorizing words

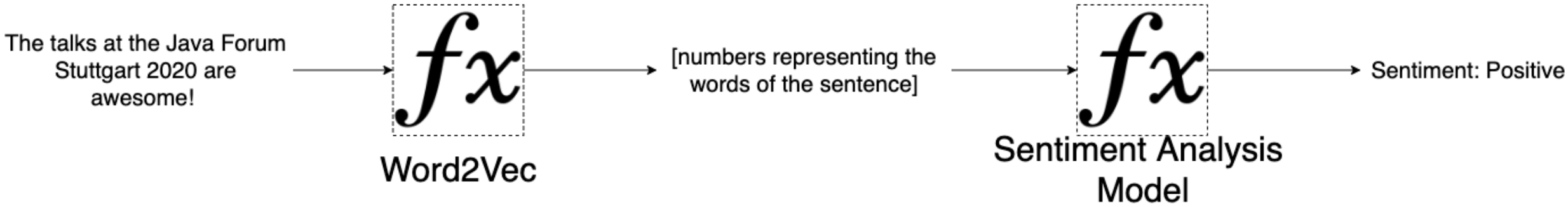
Goal:
Transform the words into vectors (numbers) that the model can understand

Word2Vec

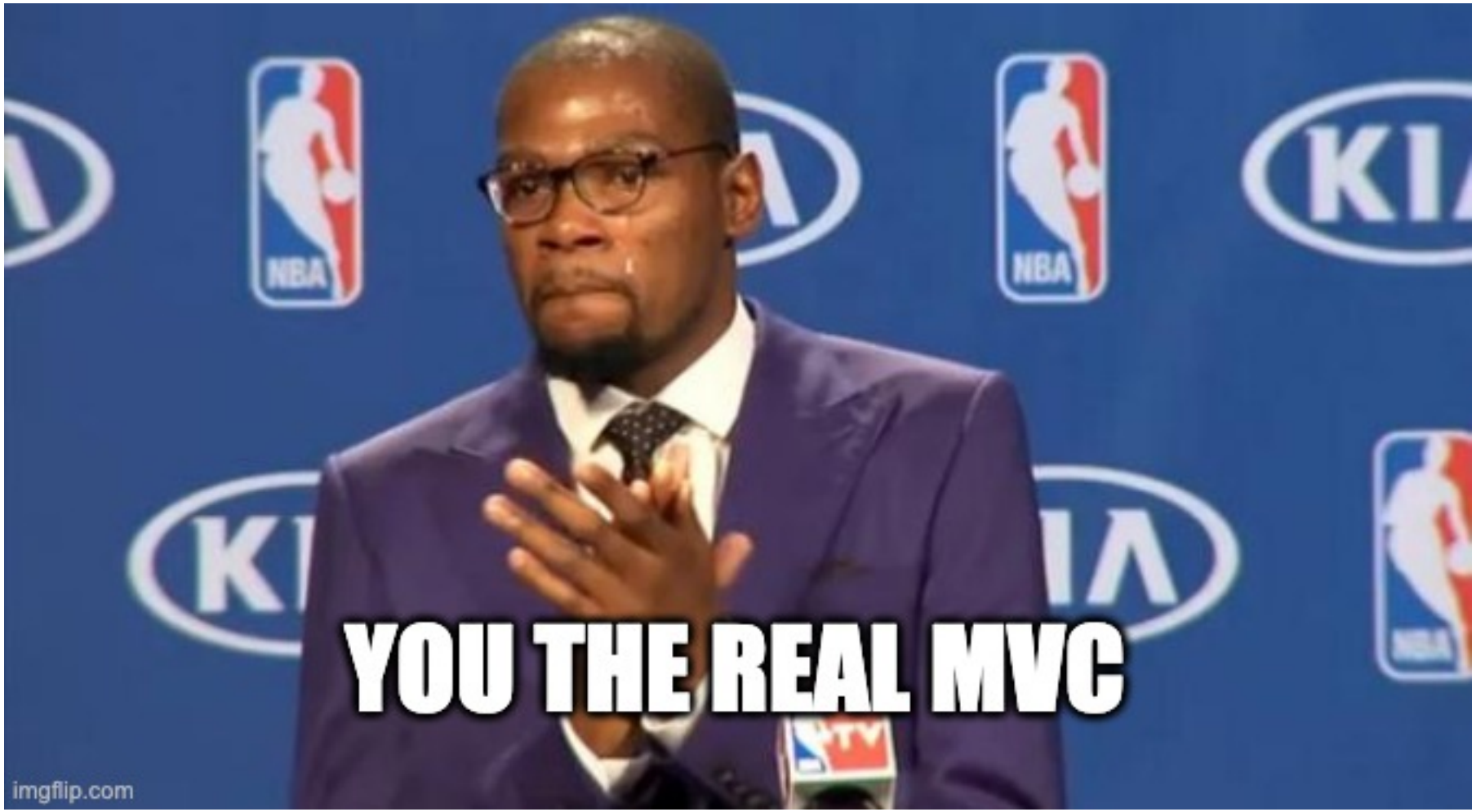
- Two-layer neural network
- Input: a corpus of text
- Output: a vector space
  - Each unique word in the corpus is assigned a corresponding vector in the space

Source: Wikipedia, Word2vec, https://en.wikipedia.org/wiki/Word2vec , retrieved 08.2020

Vectorizing words



Sentiment Analysis – Most Valuable Code



Goal:
Transform the words into vectors (numbers) that the model can understand

```
WordVectors wordVectors = WordVectorSerializer.loadStaticModel(new File(wordVectorsPath));
```

- This is loading a trained Word2Vec model from Google, can be downloaded from https://dl4jdata.blob.core.windows.net/resources/wordvectors/GoogleNews-vectors-negative300.bin.gz
- Example to train your own word2vec model at SimpleExampleWord2Vec.java at https://github.com/ellerenad/deeplearning4j-playground

```java
LineIterator lineIterator = FileUtils.lineIterator(new File(path), "UTF-8");
int counter = 0;
String line = null;
while (lineIterator.hasNext()) {
    line = lineIterator.nextLine();
    try {
        String[] parts = line.split("\",\"");
        String label = getLabel(parts);
        String data = getData(parts);
        // Dataset splitting (test and training)
        if (counter % 2 == 0) {
            trainingLabelList.add(label);
            trainingDataList.add(data);
        } else {
            testLabelList.add(label);
            testDataList.add(data);
        }
    } catch(Exception ex){
        log.error("Exception: {}. Counter = {}. Line = {}", ex, counter, line);
    }
    counter++;
}
```

```
LineIterator lineIterator = FileUtils.lineIterator(new File(path), "UTF-8");
int counter = 0;
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while (lineIterator.hasNext()) {
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```

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```

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        String data = getData(parts);
        // Dataset splitting (test and training)
        if (counter % 2 == 0) {
            trainingLabelList.add(label);
            trainingDataList.add(data);
        } else {
            testLabelList.add(label);
            testDataList.add(data);
        }
    } catch(Exception ex){
        log.error("Exception: {}. Counter = {}. Line = {}", ex, counter, line);
    }
    counter++;
}
```
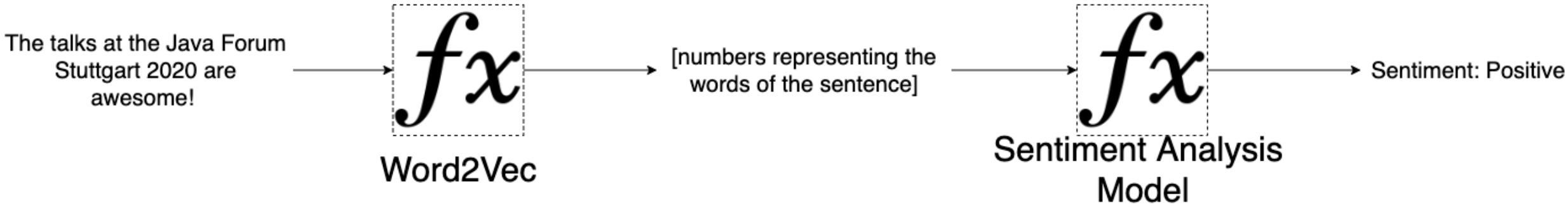

```
DataWrapper dataWrapper = getCleanData(path);

// The sentence providers shuffle the data internally
LabeledSentenceProvider trainingSentenceProvider = new CollectionLabeledSentenceProvider(
                                                        dataWrapper.getTraining_data(),
                                                        dataWrapper.getTraining_labels(),
                                                        rng);


// The iterator vectorizes internally the words
DataSetIterator trainingDataSetIterator = new CnnSentenceDataSetIterator.Builder(Format.CNN2D)
            .sentenceProvider(trainingSentenceProvider)
            .wordVectors(wordVectors)
            .minibatchSize(minibatchSize)
            .maxSentenceLength(maxSentenceLength)
            .useNormalizedWordVectors(false)
            .build();
```

Configure the model

```
ComputationGraphConfiguration config = new NeuralNetConfiguration.Builder()
                .weightInit(WeightInit.RELU)
                .activation(Activation.LEAKYRELU)
                .updater(new Adam(0.01))
                .convolutionMode(ConvolutionMode.Same)
                .l2(0.0001)
                .graphBuilder()
                .addInputs("input")
                .addLayer("cnn3", new ConvolutionLayer.Builder()
                        .kernelSize(3, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addLayer("cnn4", new ConvolutionLayer.Builder()
                        .kernelSize(4, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addLayer("cnn5", new ConvolutionLayer.Builder()
                        .kernelSize(5, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addVertex("merge", new MergeVertex(), "cnn3", "cnn4", "cnn5")
                .addLayer("globalPool", new GlobalPoolingLayer.Builder()
                        .poolingType(globalPoolingType)
                        .dropOut(0.5)
                        .build(), "merge")
                .addLayer("out", new OutputLayer.Builder()
                        .lossFunction(LossFunctions.LossFunction.MCXENT)
                        .activation(Activation.SOFTMAX)
                        .nOut(2)    //2 classes: positive or negative
                        .build(), "globalPool")
                .setOutputs("out")
                //Input has shape [minibatch, channels=1, length=1 to 256, 300]
                .setInputTypes(InputType.convolutional(truncateReviewsToLength, vectorSize, 1))
                .build();
```

Vectorizing words



Configure the model

```
ComputationGraphConfiguration config = new NeuralNetConfiguration.Builder()
                .weightInit(WeightInit.RELU)
                .activation(Activation.LEAKYRELU)
                .updater(new Adam(0.01))
                .convolutionMode(ConvolutionMode.Same)
                .l2(0.0001)
                .graphBuilder()
                .addInputs("input")
                .addLayer("cnn3", new ConvolutionLayer.Builder()
                        .kernelSize(3, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addLayer("cnn4", new ConvolutionLayer.Builder()
                        .kernelSize(4, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addLayer("cnn5", new ConvolutionLayer.Builder()
                        .kernelSize(5, vectorSize)
                        .stride(1, vectorSize)
                        .nOut(cnnLayerFeatureMaps)
                        .build(), "input")
                .addVertex("merge", new MergeVertex(), "cnn3", "cnn4", "cnn5")
                .addLayer("globalPool", new GlobalPoolingLayer.Builder()
                        .poolingType(globalPoolingType)
                        .dropOut(0.5)
                        .build(), "merge")
                .addLayer("out", new OutputLayer.Builder()
                        .lossFunction(LossFunctions.LossFunction.MCXENT)
                        .activation(Activation.SOFTMAX)
                        .nOut(2)    //2 classes: positive or negative
                        .build(), "globalPool")
                .setOutputs("out")
                //Input has shape [minibatch, channels=1, length=1 to 256, 300]
                .setInputTypes(InputType.convolutional(truncateReviewsToLength, vectorSize, 1))
                .build();
```


```
DataSetIterator trainIter = dataSetIteratorWrapper.getTrain();
DataSetIterator testIter = dataSetIteratorWrapper.getTest();

// Listeners to print information during the training and the final evaluation
net.setListeners(new ScoreIterationListener(100),
                 new EvaluativeListener(testIter, 1, InvocationType.EPOCH_END));
// Train the neural network
net.fit(trainIter, nEpochs);

// Export the neural network
net.save(new File("/example/path/"));
```

Sentiment analysis prediction example

“this code is driving me crazy! what was this guy thinking!? *Annotates the code* oh... it was me”

P(Negative) = 0.72

P(Positive) = 0.28

Label: Negative

Problems during development

- Slow feedback
- Memory management
- Loading the dataset

Sampling for faster feedback

```
head -1000 training.1600000.processed.noemoticon.csv >> training_reduced.csv
tail -1000 training.1600000.processed.noemoticon.csv >> training_reduced.csv
```

Comparing results

Samples: 800000

Accuracy	0.7472
Precision	0.7200
Recall	0.8065
F1 Score	0.7608
Execution Time	1581209 ms
	~26.3 min

40x

10x

Samples: 2000

Accuracy	0.6721
Precision	0.6382
Recall	0.7886
F1 Score	0.7055
Execution Time	165002 ms
	~2.75 min

Comparing results

Samples: 2000

Accuracy	0.6721
Precision	0.6382
Recall	0.7886
F1 Score	0.7055
Execution Time	165002 ms
	~2.75 min

Loading the word vectors: 154804 ms
~2.58 min

```
WordVectors wordVectors = WordVectorSerializer.loadStaticModel(new File(wordVectorsPath));
```

Memory Management

- Tweak the JVM with the params:

```
-Xms1024m // Initial memory allocation pool
-Xmx10g // Maximum memory allocation pool
```

More details at: https://deeplearning4j.konduit.ai/config/config-memory

Load the data set

On files bigger than 40,000 lines, the java.util.Scanner would read just up to the half of the file, messing with the training.

```
// Load dataset
LineIterator lineIterator = FileUtils.lineIterator(new File(path), "UTF-8");
```

Image source: Photo by dylan nolte on Unsplash

Thanks! Questions?

All the code can be found at
https://github.com/ellerenad/deeplearning4j-playground

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enrique.dominguez@mimacom.com

Quiz for the raffle!