FOSDEM, FEB 2 2019

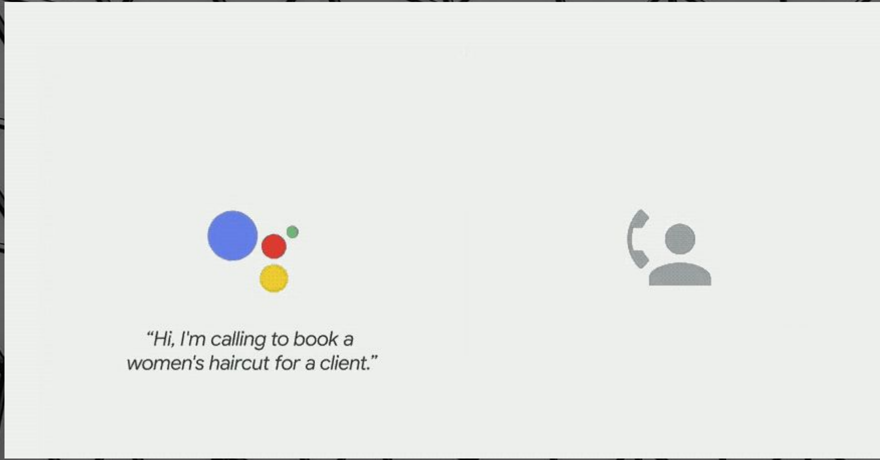
AI image search with Go & Tensorflow

Gildas Chabot

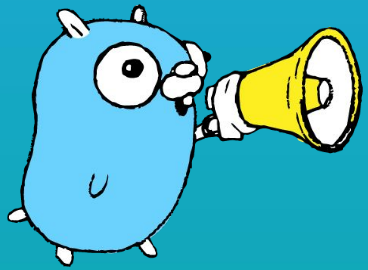
Leboncoin

gildasch

AI is about computers doing magic


"Hi, I'm calling to book a
women's haircut for a client."


AlphaStar
MaNa
Raw Observations
Neural Network Activations
Considered Location
Outcome Prediction
Win
Draw
Lose
Considered Build/Train

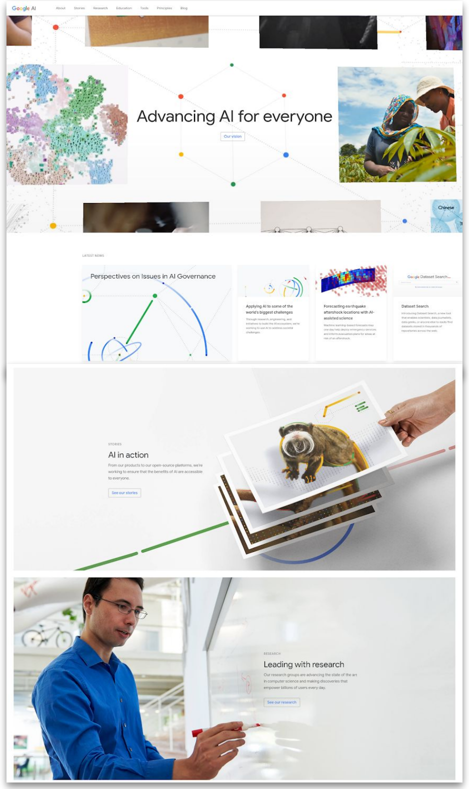


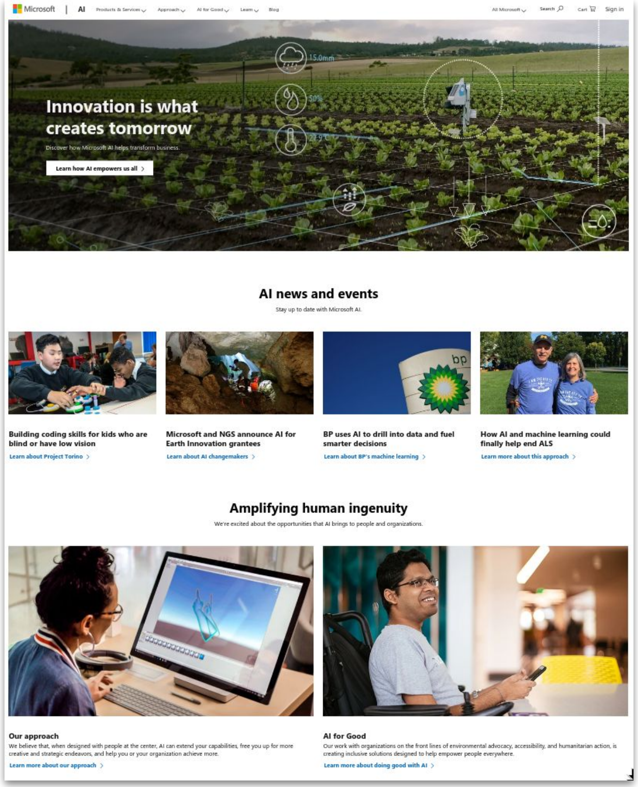
Today's (glorious) blather.

SECTION ONE

AI, Tensorflow & Go

Google, Facebook, Microsoft, Baidu in the AI Race





As many frameworks...

amazon web services

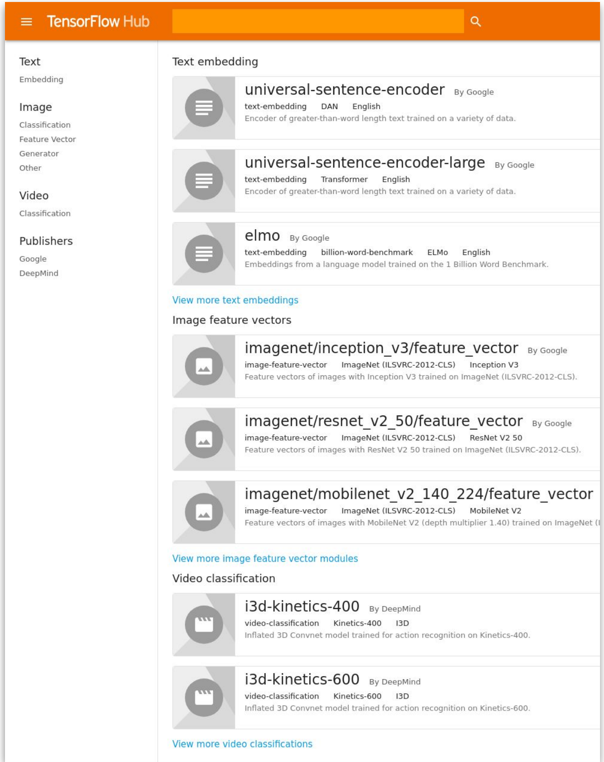
Bai du 百度

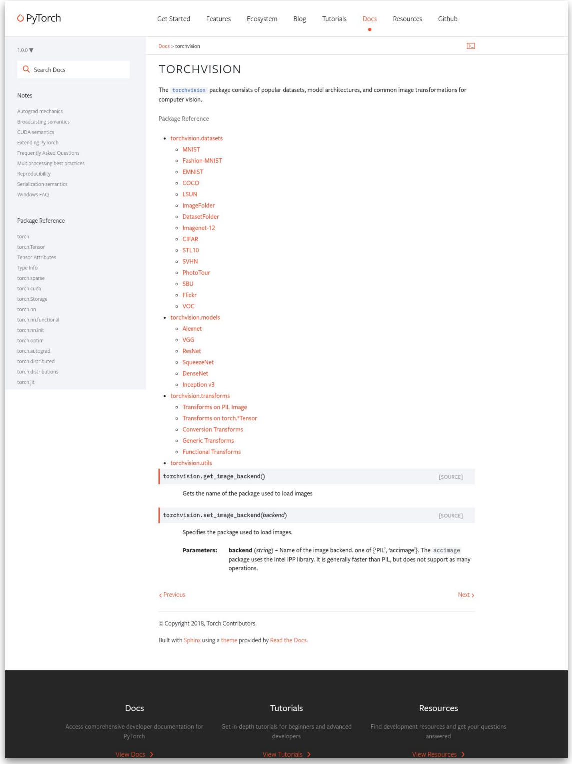
Keras

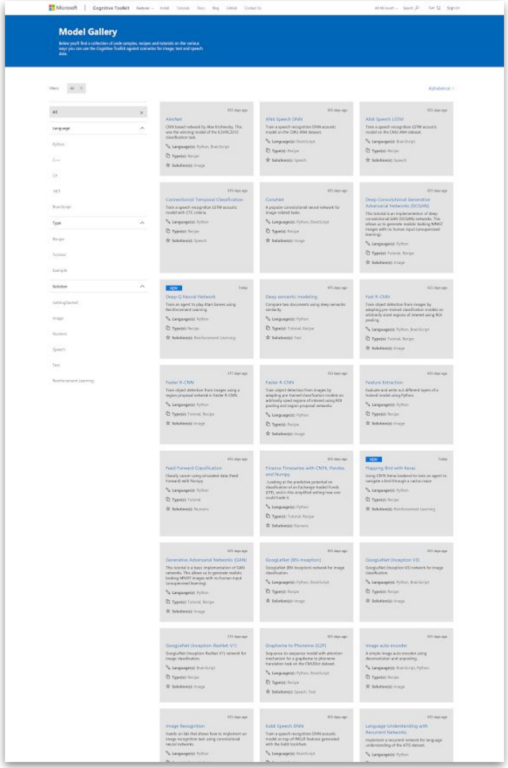
The Microsoft Cognitive Toolkit

mxnet

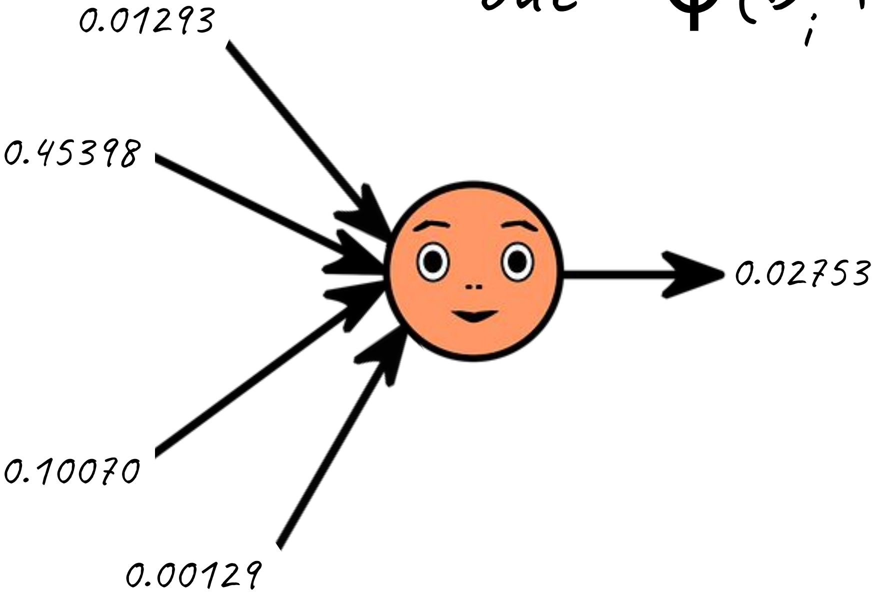
... and models too!



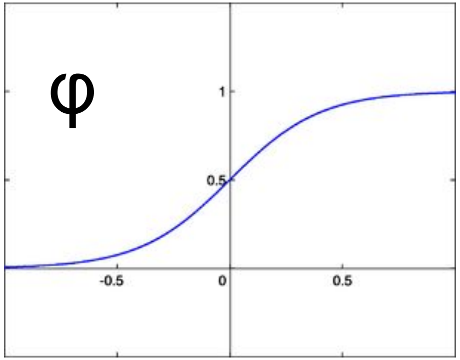




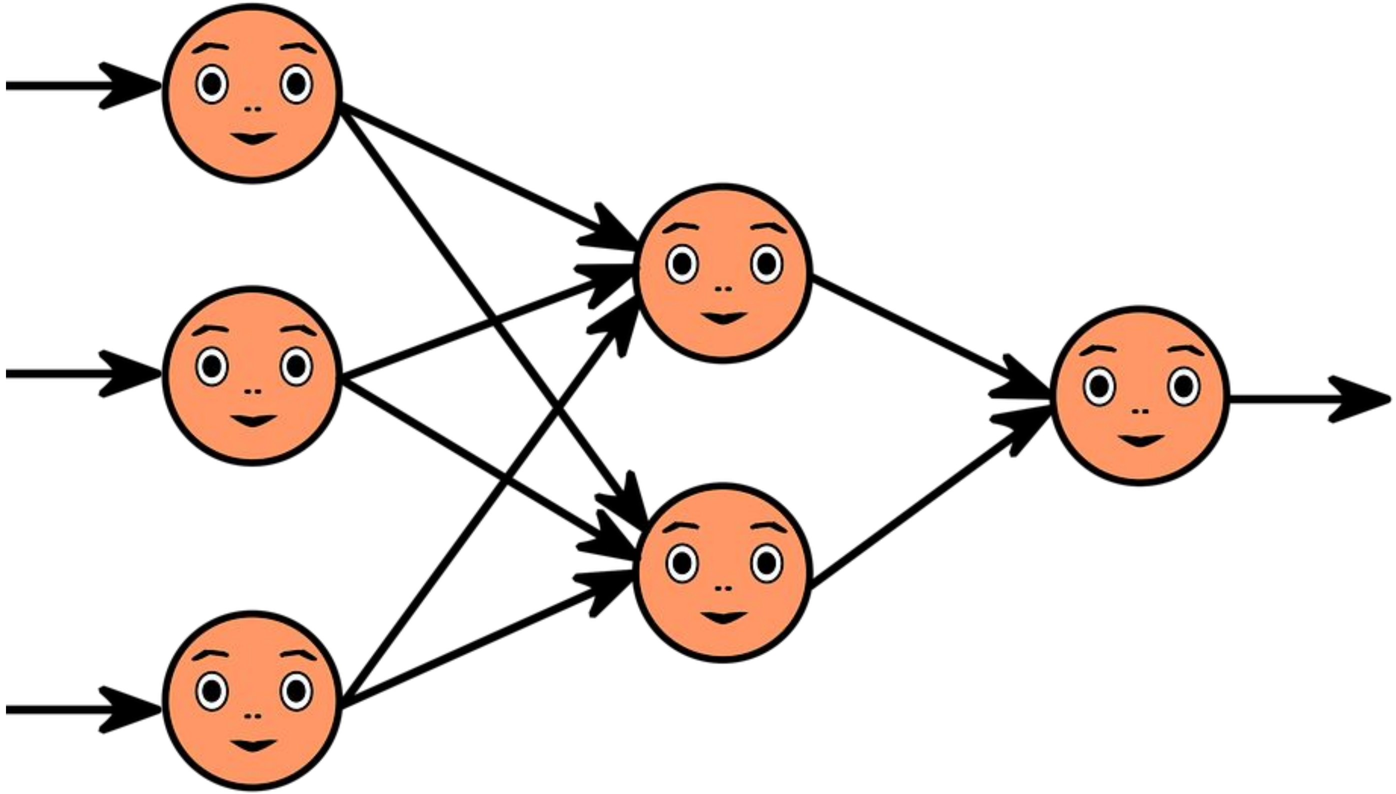
Neural networks



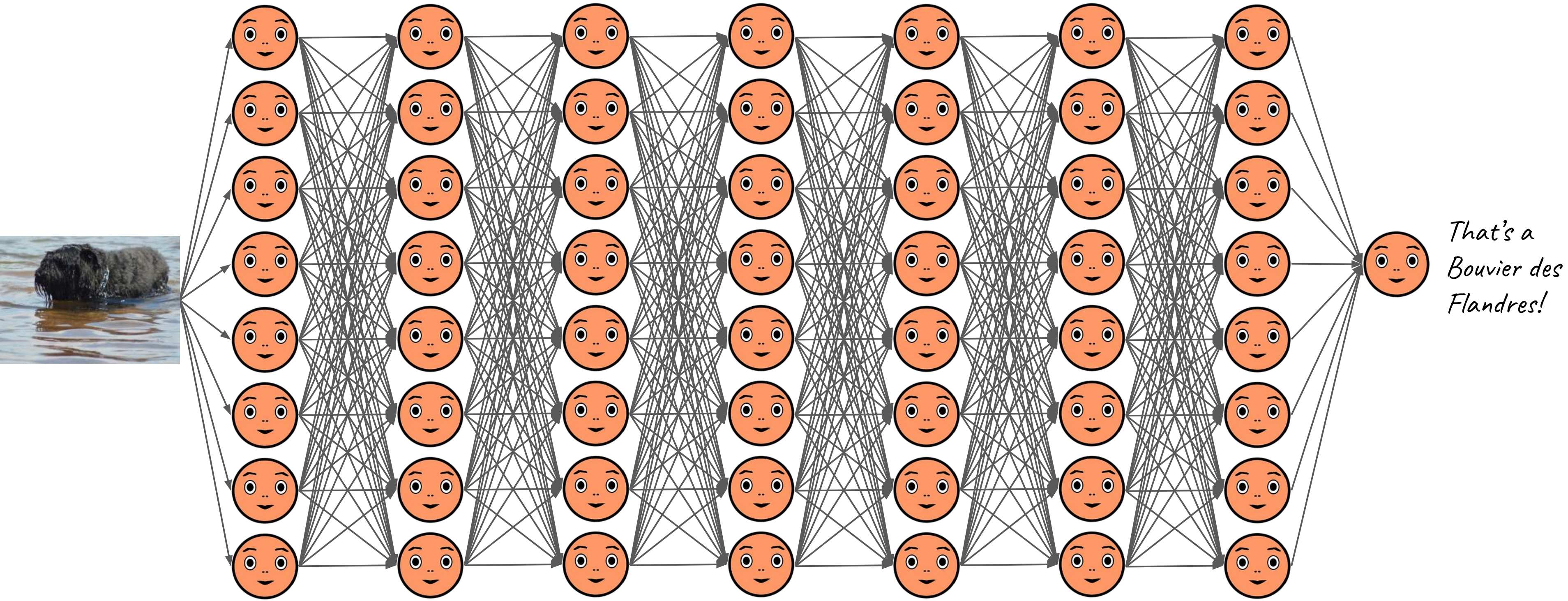
$$out = \varphi(b_i + \sum w_i * in_i)$$



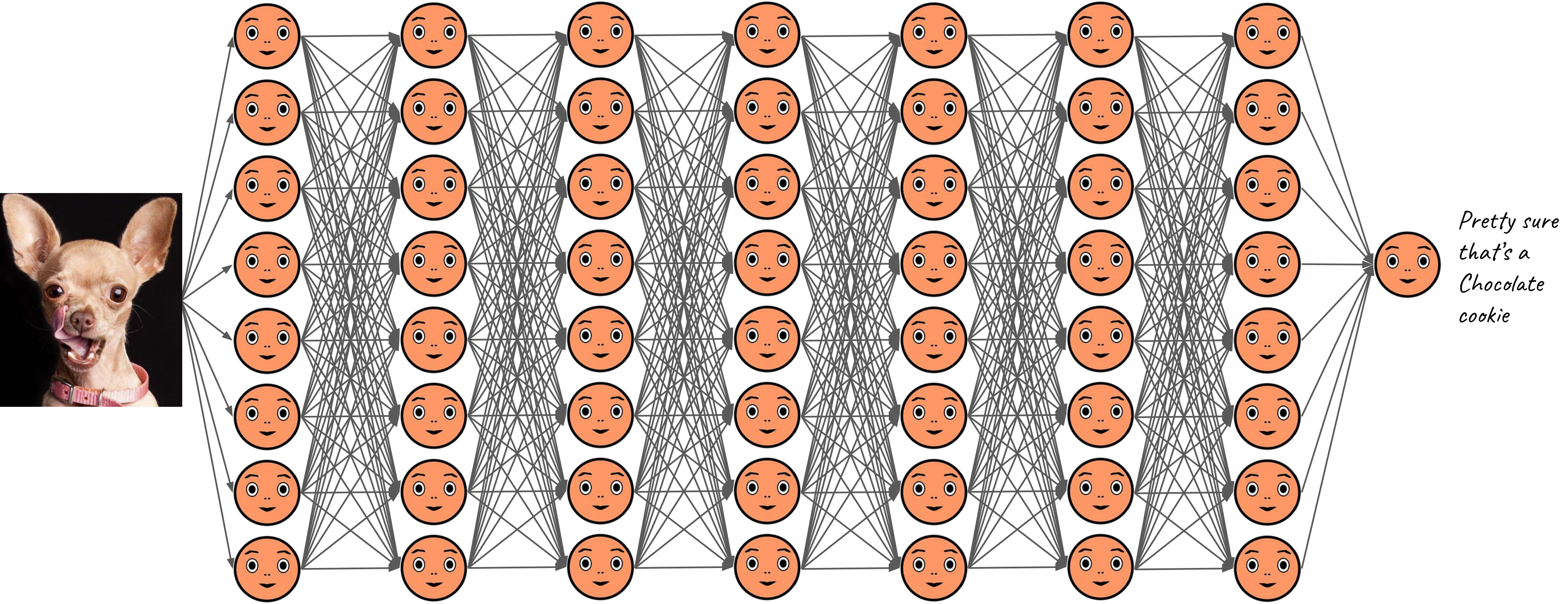
Neural networks



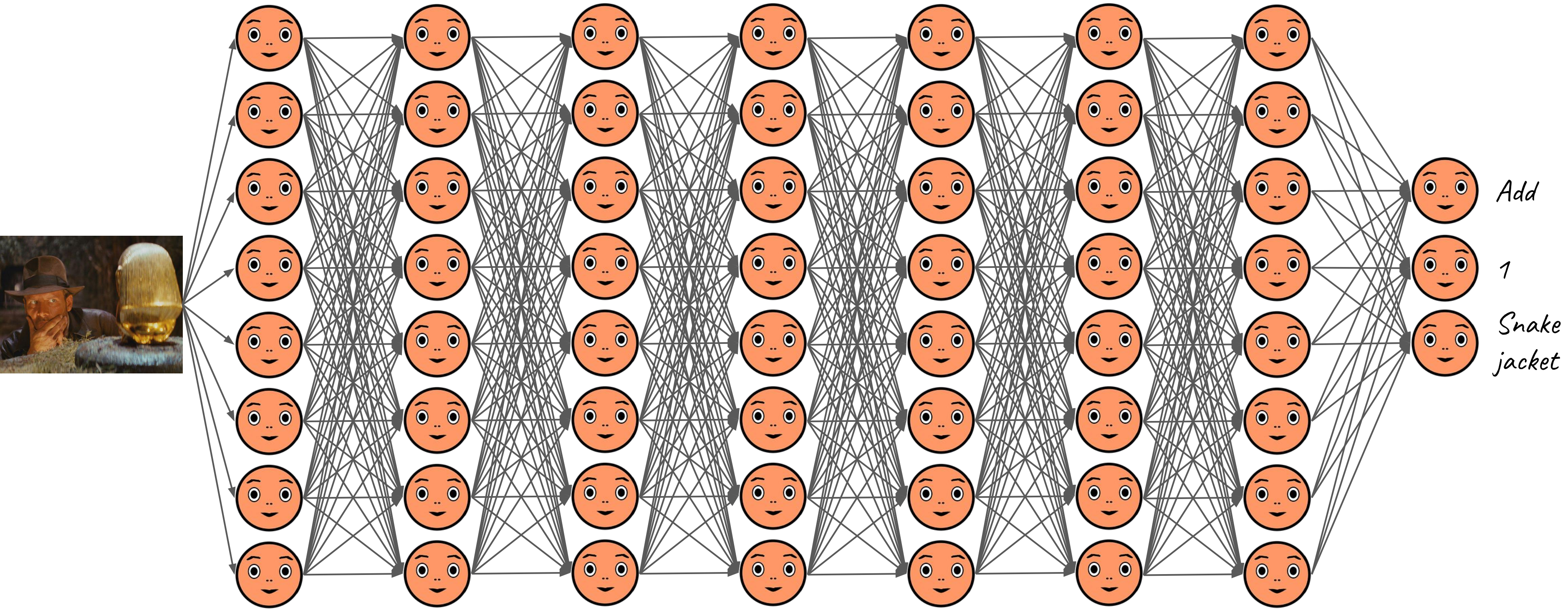
Neural networks



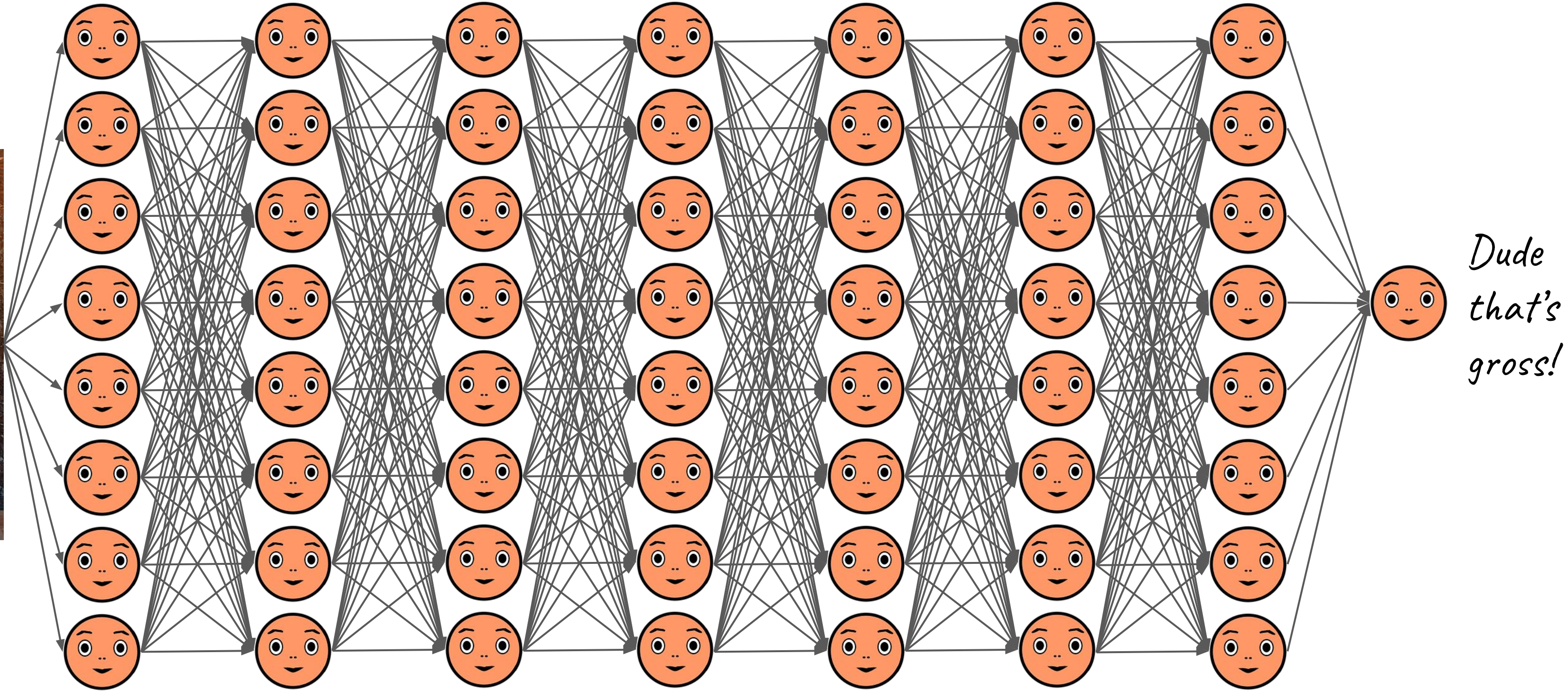
Neural networks



Neural networks

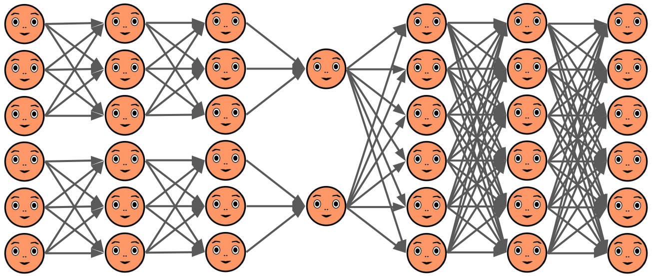


Neural networks



A few definitions

Architecture

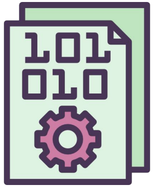


Model

$$out = \varphi\left(b_i + \sum w_i * in_i\right)$$

Pre-trained model

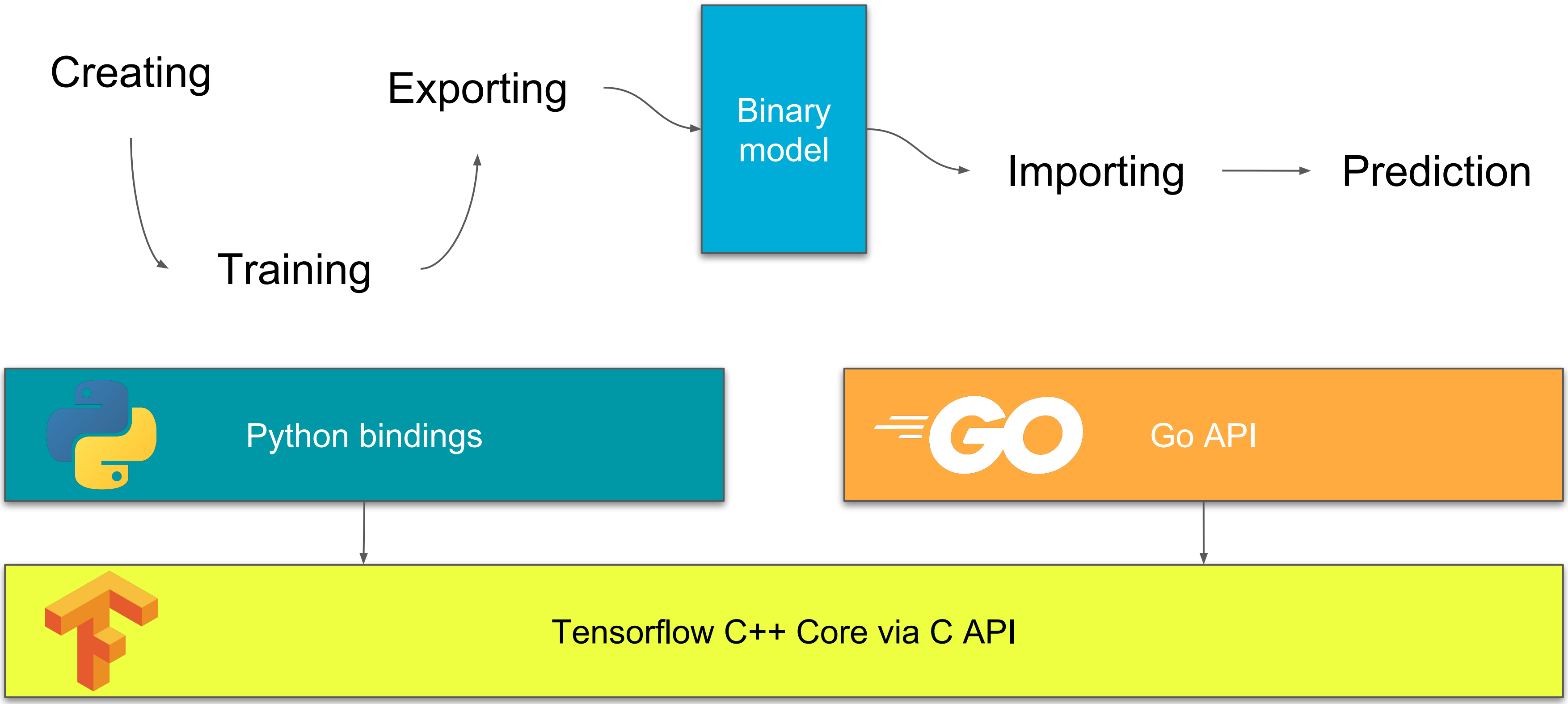
Saved model



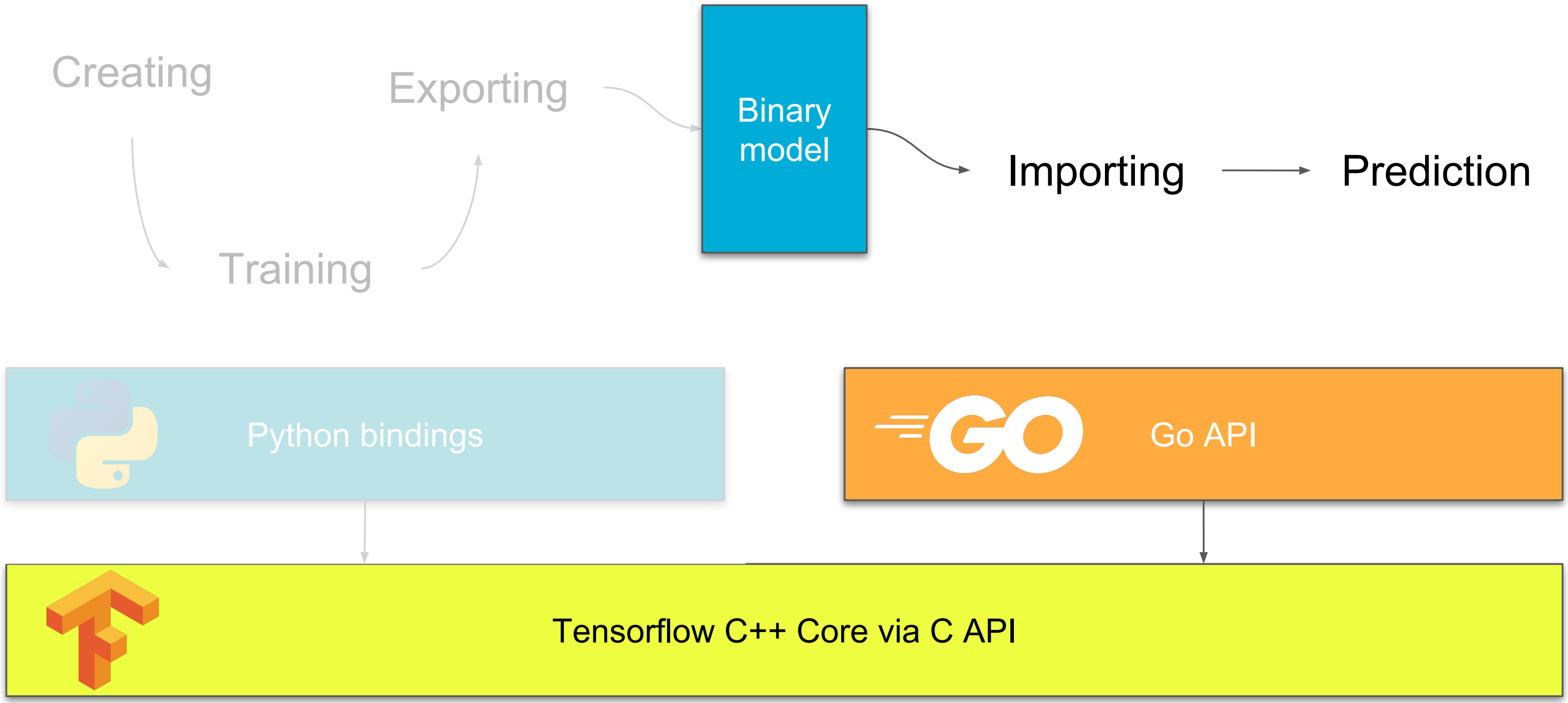
Tensorflow

A framework for creating, training, predicting, exporting & importing neural networks

Tensorflow


Creating
Exporting
Binary model
Importing
Prediction
Training
Python bindings
Go API
Tensorflow C++ Core via C API

Tensorflow


Creating
Exporting
Training
Binary model
Importing
Prediction
Python bindings
Go API
Tensorflow C++ Core via C API

Running a model using Tensorflow

Load the model from a saved model, create the input

```
model, err := tf.LoadSavedModel(
    "myModel", []string{"myTag"}, nil)
// handle error
defer model.Session.Close()

input, err := tf.NewTensor([1][][][3]float32{...})
// handle error
```

Run the session giving the *feed(s)* and *fetche(s)*

```
output, err := model.Session.Run(map[tf.Output]*tf.Tensor{
        model.Graph.Operation("input_1").Output(0): input,
    }, []tf.Output{
        model.Graph.Operation("predictions/Softmax").Output(0),
    },
    nil)
```

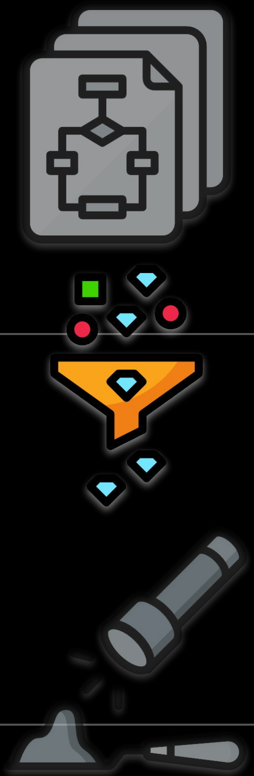
... and that's all for our interaction with Tensorflow!

Running a model using Tensorflow

```go
model, err := tf.LoadSavedModel(
    "myModel", []string{"myTag"}, nil)
// handle error
defer model.Session.Close()

input, err := tf.NewTensor([1][][][3]float32{...})
// handle error

output, err := model.Session.Run(map[tf.Output]*tf.Tensor{
        model.Graph.Operation("input_1").Output(0): input,
    }, []tf.Output{
        model.Graph.Operation("predictions/Softmax").Output(0),
    },
    nil)
```

1. Get a model and load it the model

Running a model using Tensorflow



```go
model, err := tf.LoadSavedModel(
    "myModel", []string{"myTag"}, nil)
// handle error
defer model.Session.Close()

input, err := tf.NewTensor([1][][][3]float32{...})
// handle error

output, err := model.Session.Run(map[tf.Output]*tf.Tensor{
        model.Graph.Operation("input_1").Output(0): input,
    }, []tf.Output{
        model.Graph.Operation("predictions/Softmax").Output(0),
    },
    nil)
```

2. Formate and feed the input

Running a model using Tensorflow

```
model, err := tf.LoadSavedModel(
    "myModel", []string{"myTag"}, nil)
// handle error
defer model.Session.Close()

input, err := tf.NewTensor([1][][][3]float32{...})
// handle error

output, err := model.Session.Run(map[tf.Output]*tf.Tensor{
        model.Graph.Operation("input_1").Output(0): input,
    }, []tf.Output{
        model.Graph.Operation("predictions/Softmax").Output(0),
    },
    nil)
```

3. Fetch and interpret the output

SECTION TWO

Image classification

Image classification

resnet

in 566.523636ms

- **Siamese_cat**: 0.9997669
- **Egyptian_cat**: 5.4311866e-05
- **paper_towel**: 2.1022184e-05
- **lynx**: 1.3673553e-05
- **malinois**: 6.3888087e-06
- **crate**: 6.0342945e-06
- **window_screen**: 5.1403713e-06
- **rocking_chair**: 4.8355223e-06
- **hamper**: 4.594258e-06
- **doormat**: 4.062159e-06

nasnet

in 359.76946ms

- **Siamese_cat**: 0.90478283
- **lynx**: 0.0020401527
- **Egyptian_cat**: 0.0016850991
- **Norwegian_elkhound**: 0.0015874814
- **pug**: 0.0009104196
- **jay**: 0.00069217954
- **hamper**: 0.0006849118
- **malinois**: 0.00066736544
- **window_screen**: 0.0006443651
- **radiator**: 0.0006424375

pnasnet

in 1.845216832s

- **Siamese_cat**: 0.8806749
- **Egyptian_cat**: 0.002932137
- **Persian_cat**: 0.00089966087
- **lynx**: 0.0005232249
- **window_screen**: 0.00050571625
- **bell_pepper**: 0.00046575037
- **toilet_seat**: 0.00041283385
- **notebook**: 0.00040566092
- **Angora**: 0.00039811153
- **rocking_chair**: 0.00039036854

- **Siamese_cat**: 0.90478283
- **lynx**: 0.0020401527
- **Egyptian_cat**: 0.0016850991
- **Norwegian_elkhound**: 0.0015874814
- **pug**: 0.0009104196
- **jay**: 0.00069217954
- **hamper**: 0.0006849118
- **malinois**: 0.00066736544
- **window_screen**: 0.0006443651
- **radiator**: 0.0006424375

ImageNet Challenge

IMAGENET

- 1,000 object classes (categories).
- Images:
  - 1.2 M train
  - 100k test.

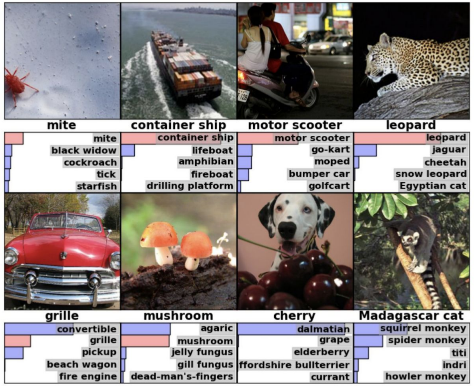
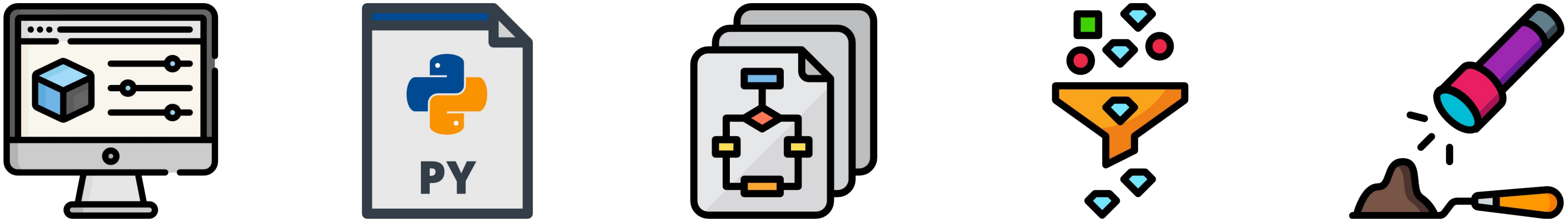


Image classification

1. Finding the model
2. Run it in Python
3. Save the model
4. Format the input
5. Interpret the output



Finding a model

Tiny YOLO in Javascript
by mikeshi · Live Demo · ♥ 9 · 356

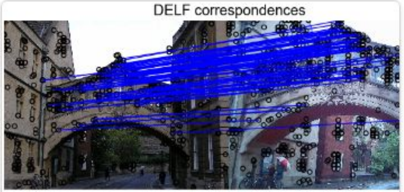
Detect objects in images right in your user's browser using Tensorflow.js!

CV | Mobile | Food and Drink

Mask R-CNN
♥ 4 · 92
by dani · Live Demo

Pixel-level fine-grained object detection in your images/videos

CV | R-CNN | CNN



DELF
♥ 5 · 118
by mikeshi

Match an image against a database of images through identifying key points.

CV | Feature Extraction | CNN

Example

Input: 🔊 Spoken Audio

Output: 📝 Text Transcribed from Audio

Wavenet Speech to Text
by dhruvk · ♥ 4 · 72

Transcribe audio to text using Deepmind's Wavenet

NLP | CNN | NN

Yahoo Open NSFW
♥ 136 · 201
by mikeshi · Live Demo

Detect not safe for work (NSFW) content in images

CV | Transfer Learning | NN

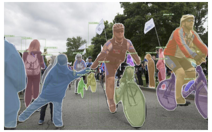
NASNet Mobile
♥ 41 · 81
by jbrandowski

Neural Architecture Search Network, trained on ImageNet

CV | Transfer Learning | Feature Extraction

ModelDepot.io

Microsoft | Cognitive Toolkit



Model Gallery

Below you'll find a collection of code samp ways you can use the Cognitive Toolkit aga data.

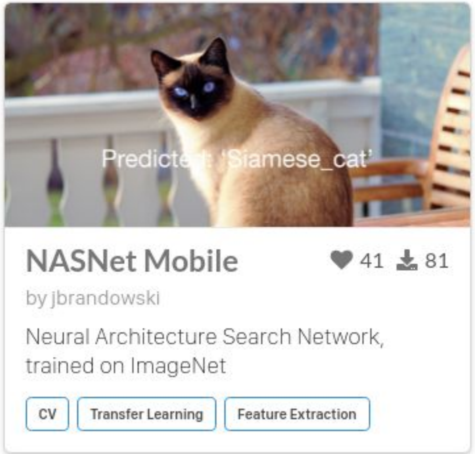
TensorFlow Hub

Github.com

arXiv

arXiv.org

Image classification



Run in Python...

```
import keras
from keras.applications.nasnet import NASNetMobile
from keras.preprocessing import image
from keras.applications.xception import preprocess_input,
decode_predictions
import numpy as np
```

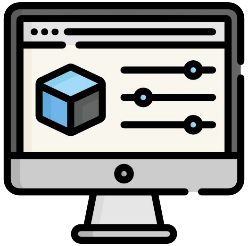
Run in Python...

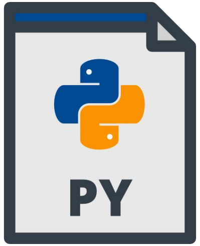
```
model = NASNetMobile(weights="NASNet-mobile.h5")
img = image.load_img('cat.jpg', target_size=(224,224))
img_arr = np.expand_dims(image.img_to_array(img), axis=0)

x = preprocess_input(img_arr)

preds = model.predict(x)
print('Predicted:', decode_predictions(preds, top=3)[0])
```

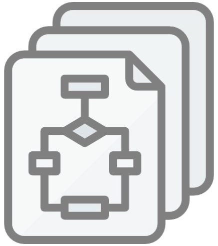
Most models come with Python code. Here, Keras makes it very simple.

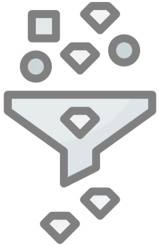
Image classification

```
$ python run_prediction.py
Predicted: [('n02123597', 'Siamese_cat',
0.8996405), ('n02127052', 'lynx',
0.0022755866), ('n02124075',
'Egyptian_cat', 0.0021423753)]
```









… and save the model

```python
import tensorflow as tf
from keras import backend as K
```

I am using Tensorflow 1.12.0

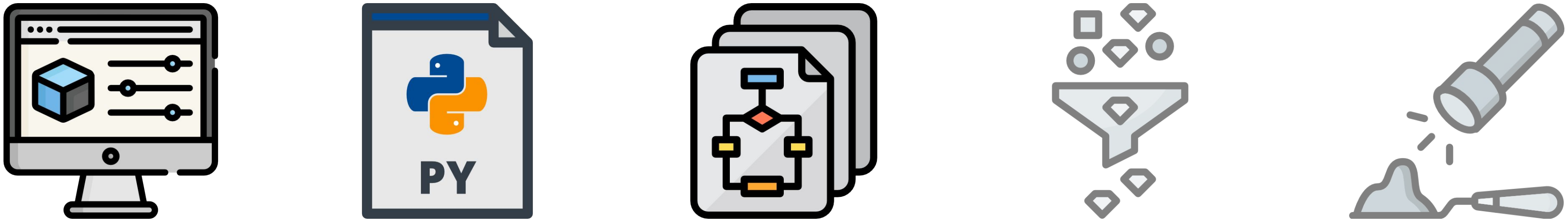
... and save the model

```
sess = tf.Session()
K.set_session(sess)

model = NASNetMobile(weights="NASNet-mobile.h5")
img = image.load_img('cat.jpg', target_size=(224,224))
img_arr = np.expand_dims(image.img_to_array(img), axis=0)

x = preprocess_input(img_arr)

preds = model.predict(x)
print('Predicted:', decode_predictions(preds, top=3)[0])

builder = tf.saved_model.builder.SavedModelBuilder("myModel")
builder.add_meta_graph_and_variables(sess, ["myTag"])
builder.save()
sess.close()
```

Just add a few lines around the execution to save the model.

Image classification

```
$ ls -R myModel/
myModel/:
saved_model.pb   variables

myModel/variables:
variables.data-00000-of-00001   variables.index
```



Finding out the input & output layer names

```
# If Keras model, in Python
print('input layer: ', model.input)
print('output layer: ', model.output)
```

```
# Print all layer names
for op in graph.get_operations():
    print(op.name)
```

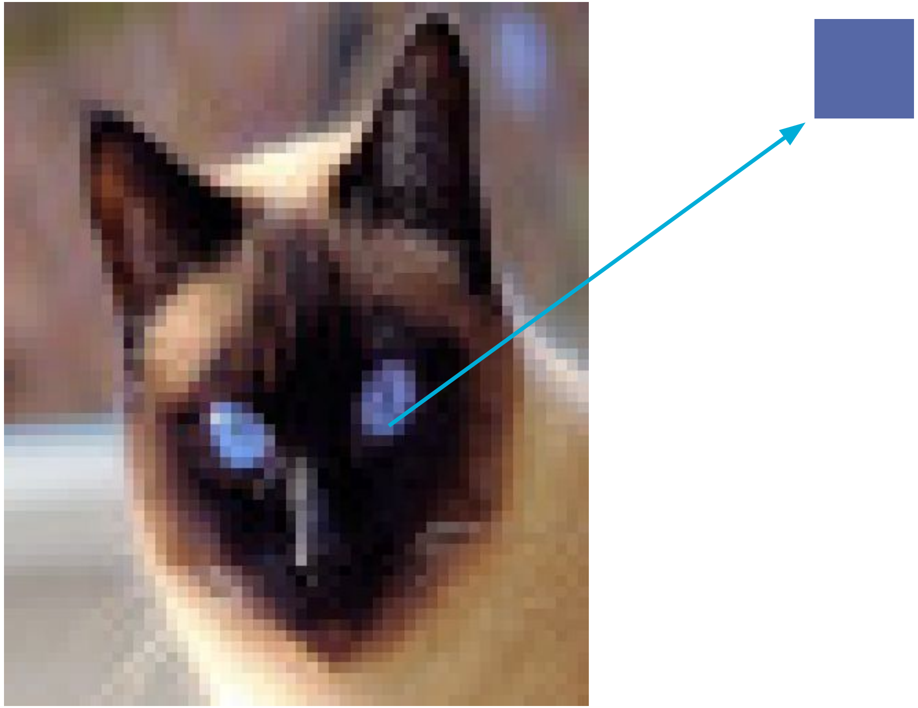
… or debug the Python code

```
input layer:  Tensor("input_1:0", shape=(?, 224, 224, 3), dtype=float32)
output layer:  Tensor("predictions/Softmax:0", shape=(?, 1000), dtype=float32)
```

```
input_1
stem_conv1/truncated_normal/shape
stem_conv1/truncated_normal/mean
stem_conv1/truncated_normal/stddev
stem_conv1/truncated_normal/TruncatedNor
mal
stem_conv1/truncated_normal/mul
stem_conv1/truncated_normal
stem_conv1/kernel
stem_conv1/kernel/Assign
stem_conv1/kernel/read
stem_conv1/convolution/dilation_rate
stem_conv1/convolution
stem_bn1/Const
stem_bn1/gamma
stem_bn1/gamma/Assign
stem_bn1/gamma/read
stem_bn1/Const_1
stem_bn1/beta
stem_bn1/beta/Assign
stem_bn1/beta/read
stem_bn1/Const_2
stem_bn1/moving_mean
stem_bn1/moving_mean/Assign
stem_bn1/moving_mean/read
stem_bn1/Const_3
stem_bn1/moving_variance
stem_bn1/moving_variance/Assign
stem_bn1/moving_variance/read
stem_bn1/IsVariableInitialized
stem_bn1/IsVariableInitialized_1
stem_bn1/IsVariableInitialized_2
stem_bn1/IsVariableInitialized_3
stem_bn1/IsVariableInitialized_4
stem_bn1/init
...
```

Formatting the input image

```
input layer:  Tensor("input_1:0", shape=(?, 224, 224, 3), dtype=float32)
```



R: 86 ; G: 104 ; B: 166

$$f(x) = (x - 127.5) / 127.5$$

$$[0,255] \Rightarrow [-1,1]$$

R: -0.3255 ; G: -0.1843 ; B: 0.3020

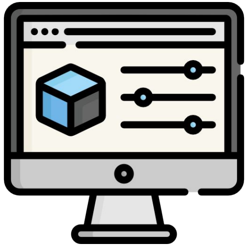
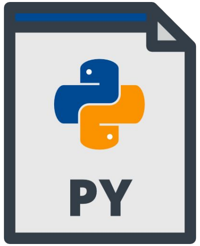
Formatting the input image

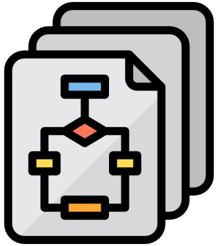
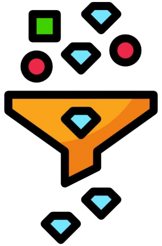
```
func imageToTensor(img image.Image) (*tf.Tensor, error) {
	var image [1][224][224][3]float32
	for i := 0; i < 224; i++ {
		for j := 0; j < 224; j++ {
			r, g, b, _ := img.At(i, j).RGBA()
			image[0][j][i][0] = convertColor(r)
			image[0][j][i][1] = convertColor(g)
			image[0][j][i][2] = convertColor(b)
		}
	}
	return tf.NewTensor(image)
}
func convertColor(value uint32) float32 {
	return (float32(value>>8) - float32(127.5)) / float32(127.5)
}
```

Note that you'll likely need to perform some scaling to have a 224*224 image.

Image classification

```
tf.NewTensor(
     [1][224][224][3]float32{[224][224][3]float32{[224][3]float32{
          [3]float32{-0.003921569, -0.03529412, -0.105882354},
          [3]float32{-0.105882354, -0.14509805, -0.19215687},
          [3]float32{-0.09019608, -0.13725491, -0.13725491},
          [3]float32{-0.08235294, -0.12941177, -0.06666667},
          ...
     }
)
```


Interpreting the output

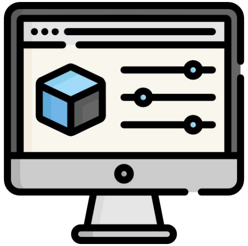
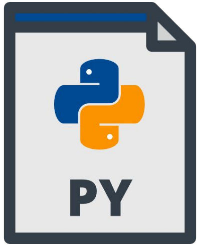
```
output layer:  Tensor("predictions/Softmax:0", shape=(?, 1000), dtype=float32)
```

```
"tench":              0.0001,
"goldfish":           0.0012,
"great_white_shark":  0.0009,
"tiger_shark":        0.0002,
"hammerhead":         0.0000,
"electric_ray":       0.0000,
"stingray":           0.0001,
"cock":               0.0201,
"hen":                0.0002,
"ostrich":            0.0001,
"brambling":          0.0000,
"goldfinch":          0.0000,
"house_finch":        0.0026,
...
```

Keep the 10 best scores

Image classification

```
[10]Prediction{
    {Class: “Siamese_cat”, Score: 0.8996405},
    {Class: “lynx”, Score: 0.0022755866},
    {Class: “Egyptian_cat”, Score: 0.0021423753},
    ...
}
```

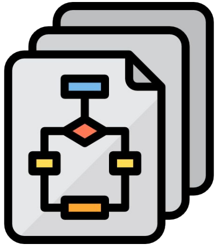
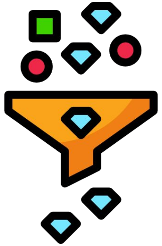




Image classification

nasnet

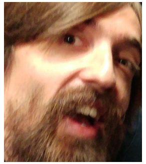
in 359.76946ms

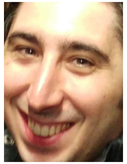
- **Siamese_cat**: 0.90478283
- **lynx**: 0.0020401527
- **Egyptian_cat**: 0.0016850991
- **Norwegian_elkhound**: 0.0015874814
- **pug**: 0.0009104196
- **jay**: 0.00069217954
- **hamper**: 0.0006849118
- **malinois**: 0.00066736544
- **window_screen**: 0.0006443651
- **radiator**: 0.0006424375

SECTION THREE

Face recognition

Detection



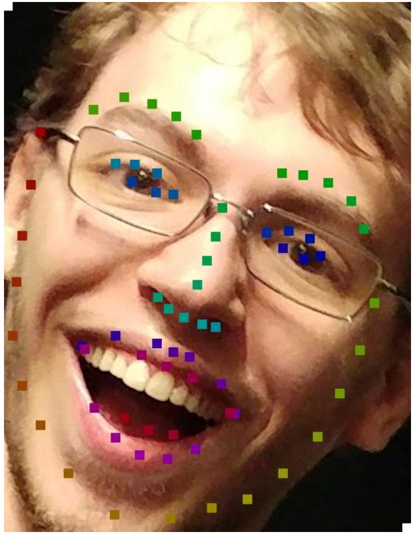


Input shape: [1][?][?][3]uint8

Output shapes:
- Boxes: [1][n][4]float32
- Scores: [1][n]float32

n: number of detections

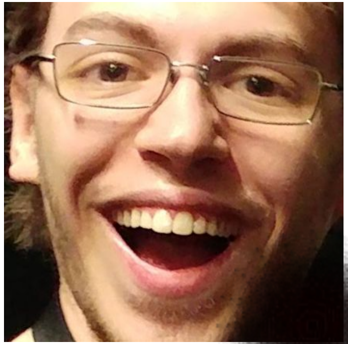
Landmarks



Input shape: [1][112][112][3]uint8

Output shapes: [1][68]float32

Descriptors



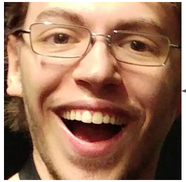
Input shape: [1][150][150][3]uint8

Output shapes: [1][128]float32

[-0.12612689
0.118047886
0.02671108
-0.07834958
-0.14790918
-0.022446968
-0.026294671
-0.045843683
0.14365208
-0.0576083
0.2268444
-0.01782807
-0.25747967
-0.12318702
0.03319504
0.16775846
-0.14766541
-0.103011996
-0.17960805
-0.0653507
...
-0.08973549
0.048736386
0.0029452406]

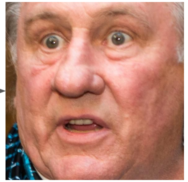
Euclidean distance in this 128-dims space

$$distance = \sqrt{\left(\sum_{i \in [0,127]} (face1_i - face2_i)^2\right)}$$



0.83

0.49



[-0.12612689
0.118047886
0.02671108
-0.07834958
...]

[-0.026294671
-0.045843683
0.14365208
-0.0576083
...]

[0.03319504
0.16775846
-0.14766541
-0.103011996
...]

The 128-dims vector is
- ✓ Lightweight
- ✓ Fast
- ✓ Good for search

face-api.js - github.com/justadudewhohacks/face-api.js

face-api.js

API Documentation

Face And Landmark Detection

Face Expression Recognition

Face Recognition

Video Face Tracking

Webcam Face Tracking

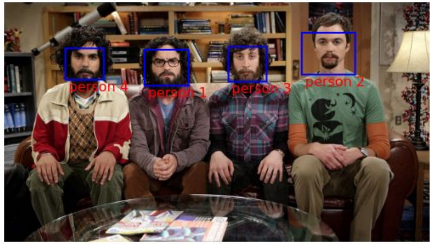
Webcam Face Expression Recognition

BBT Face Landmark Detection

BBT Face Similarity

BBT Face Recognition

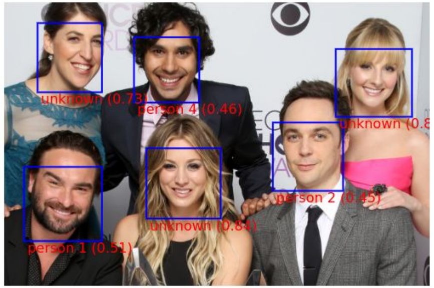
face-api.js playground



bbt1.jpg

Pick an image

FROM DISK



bbt4.jpg

Pick an image

FROM DISK

Choose face detector: Tiny Face Detector

Input Size 512

scoreThreshold: 0.5

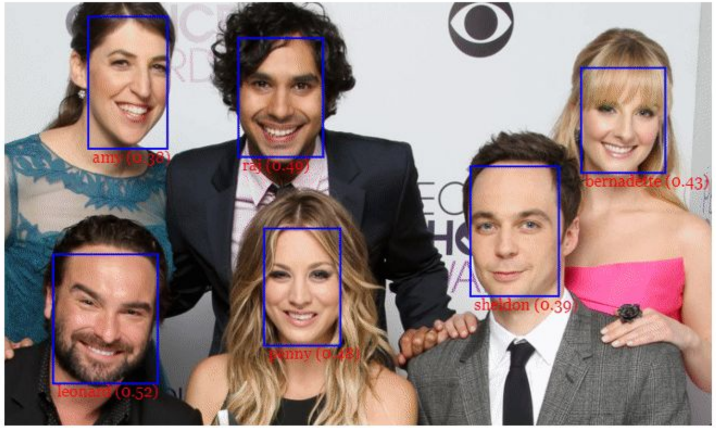
- +

face-api.js—JavaScript API for Face Recognition in the Browser with tensorflow.js

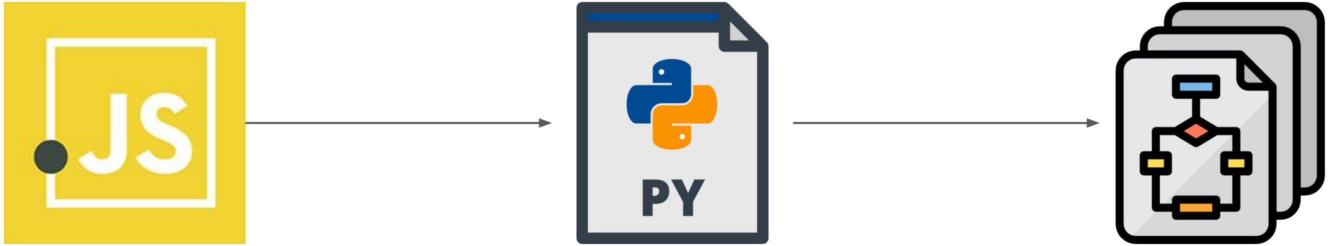
A JavaScript API for Face Detection, Face Recognition and Face Landmark Detection

Vincent Mühler Follow

Jun 25, 2018 · 9 min read



face-api.js




```
const out1 = tf.relu(
  isFirstLayer
    ? tf.add(
      tf.conv2d(x, denseBlockParams.conv0.filters,
[2, 2], 'same'),
      denseBlockParams.conv0.bias
    )
    : depthwiseSeparableConv(x,
denseBlockParams.conv0, [2, 2])
)

const out2 = depthwiseSeparableConv(out1,
denseBlockParams.conv1, [1, 1])
...
```

```
  if isFirstLayer:
    out1 = tf.math.add(
      tf.nn.conv2d(inp, dense["conv0"]["filters"], [1,2,2,1],
'SAME'),
      dense["conv0"]["bias"])
  else:
    out1 = tf.math.add(
      tf.nn.separable_conv2d(
        inp, dense["conv0"]["depthwise_filter"],
dense["conv0"]["pointwise_filter"],
        [1,2,2,1], 'SAME'),
      dense["conv0"]["bias"])

  out1 = tf.nn.relu(out1)

  out2 = tf.math.add(
    tf.nn.separable_conv2d(...
```

SECTION FOUR

Search

Search is left as an exercise to the reader

Search by keyword

timber_wolf
red_wolf
coyote

digital_clock
radio
Polaroid_camera

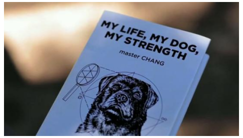
Great_Pyrenees
kuvasz

crate
Irish_wolfhound
Border_terrier

Old_English_sheepdog
West_Highland_white_terri
er

jeep
cab
car_wheel

file
desk
restaurant



book_jacket
packet

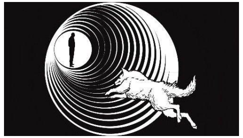
kimono
toaster

restaurant
dinning_table

Norwich_terrier
Irish_terrier
Australian_terrier

fur_coat
wool

car_mirror
cab
school_bus



maze
coil
zebra

German_shepherd
Eskimo_dog
fur_coat

Search by keyword

“dog”

timber_wolf
red_wolf
coyote

digital_clock
radio
Polaroid_camera

Great_Pyrenees
kuvasz

crate
Irish_wolfhound
Border_terrier

Old_English_sheepdog
West_Highland_white_terrier

jeep
cab
car_wheel

file
desk
restaurant

book_jacket
packet

kimono
toaster

restaurant
dinning_table

Norwich_terrier
Irish_terrier
Australian_terrier

fur_coat
wool

car_mirror
cab
school_bus

maze
coil
zebra

German_shepherd
Eskimo_dog
fur_coat

Search by keyword

"car"

timber_wolf
red_wolf
coyote

digital_clock
radio
Polaroid_camera

Great_Pyrenees
kuvasz

crate
Irish_wolfhound
Border_terrier

Old_English_sheepdog
West_Highland_white_terri
er

jeep
cab
car_wheel

file
desk
restaurant

book_jacket
packet

kimono
toaster

restaurant
dinning_table

Norwich_terrier
Irish_terrier
Australian_terrier

fur_coat
wool

car_mirror
cab
school_bus

maze
coil
zebra

German_shepherd
Eskimo_dog
fur_coat

Search by keyword

“restaurant”

timber_wolf
red_wolf
coyote

digital_clock
radio
Polaroid_camera

Great_Pyrenees
kuvasz

crate
Irish_wolfhound
Border_terrier

Old_English_sheepdog
West_Highland_white_terri
er

jeep
cab
car_wheel

file
desk
restaurant

book_jacket
packet

kimono
toaster

restaurant
dinning_table

Norwich_terrier
Irish_terrier
Australian_terrier

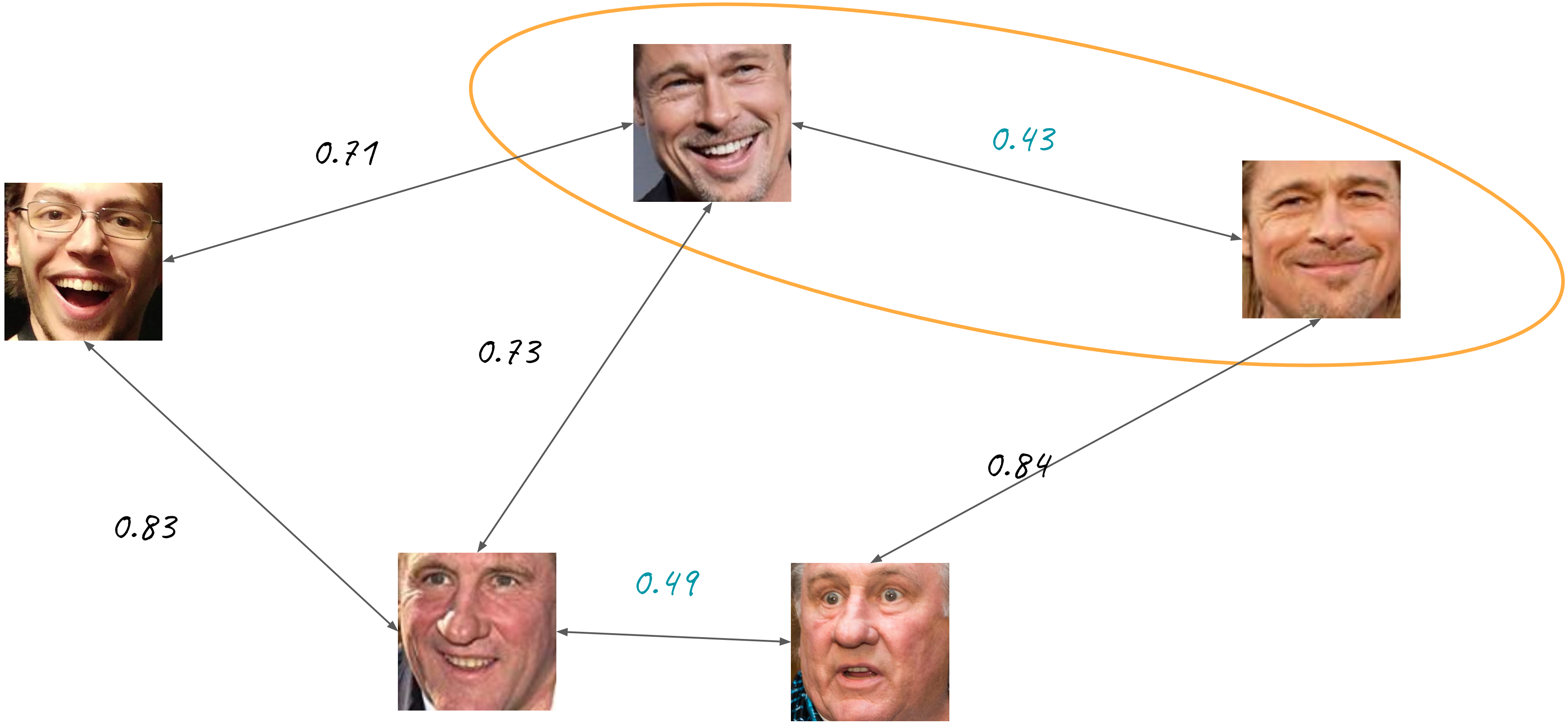
fur_coat
wool

car_mirror
cab
school_bus

maze
coil
zebra

German_shepherd
Eskimo_dog
fur_coat

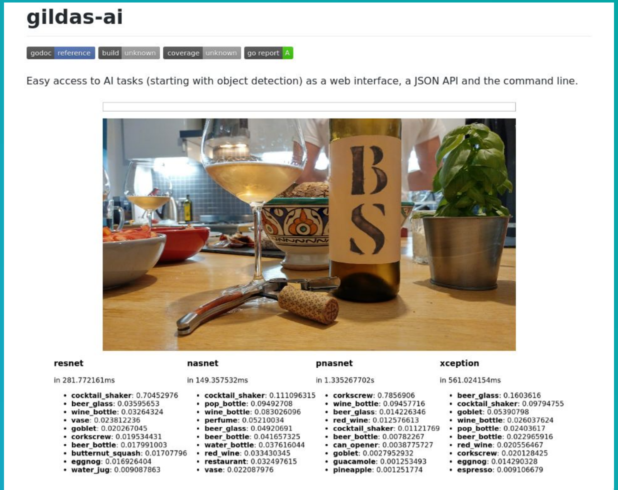
Search by face



Conclusion

All the models I have talked about are (hopefully) ready to use on my repo

github.com/gildasch/gildas-ai



Run the demo

```
$ docker run -p 8080:8080 gildasch/gildas-ai
```

Objects

Faces

Faceswap

Masks

Try it as a lib too!

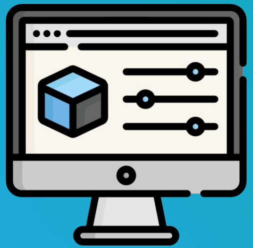
```go
// import "github.com/gildasch/gildas-ai/imagenet"

model, close, err := imagenet.NewNasnet("models/")
// handle error
defer close()

preds, err := model.Classify(img)
// handle error

fmt.Println(preds.Best(10))
```

Keras and Tensorflow models work great

The others will require conversion which is still experimental

Remember the 5 step to use a new model

1. Finding the model



2. Run it in Python

3. Save the model

4. Format the input

5. Interpret the output

Thank you

Closing notes

- All the models I have talked about are (hopefully) ready to use on my repo github.com/gildasch/gildas-ai
- Keras and Tensorflow models work great
- The others will require conversion which is still experimental

Models

Name	Author	License	Link	Framework	
Keras Xception	harshsikka	MIT	https://modeldepot.io/harshsikka/keras-xception	Keras	
Keras ResNet50	tonyshih	MIT	https://modeldepot.io/tonyshih/keras-resnet50	Keras	
NASNet Mobile	jbrandowski	Apache License 2.0	https://modeldepot.io/jbrandowski/nasnet-mobile	Keras	
Imagenet (ILSVRC-2012-CLS) classification with PNASNet-5 (large)	Google	Creative Commons Attribution 3.0	https://tfhub.dev/google/imagenet/pnasnet_large/classification/2	Tensorflow Hub	
Mask R-CNN	dani	MIT	https://modeldepot.io/dani/mask-r-cnn	Keras	
face-api.jst	justadudewhohacks	MIT	https://github.com/justadudewhohacks/face-api.js	Tensorflow	
InsightFace (ArcFace)	Jia Guo and Jiankang Deng	MIT	https://github.com/deepinsight/insightface	MXNet	Converted following https://github.com/Microsoft/MMdnn/issues/85

Go’s Values


cup (0.71%)
cup (0.94%)
dining table (0.99%)
vase (0.82%)
cup (0.84%)
cup (0.93%)
CANTILLON

TYPES & METHODS

You can define methods on any type:

```
type MyFloat float64
 func (m MyFloat) Abs() float64 {
     f := float64(m)
     if f < 0 {
         return -f
     }
     return f
 }
 f := MyFloat(-42)
 f.Abs() // == 42.0
```

Each language feature should be easy to understand.