HDE
Liberation of Technology

From Data to Web Application: Anime Character Image Recognition with Transfer Learning

PyCon JP 2018
#pyconjp #pyconjp_1

Iskandar Setiadi
Software Engineer at HDE, Inc.

Github

https://github.com/freedomofkeima

Blog

https://freedomofkeima.com/blog/

Speaker in:

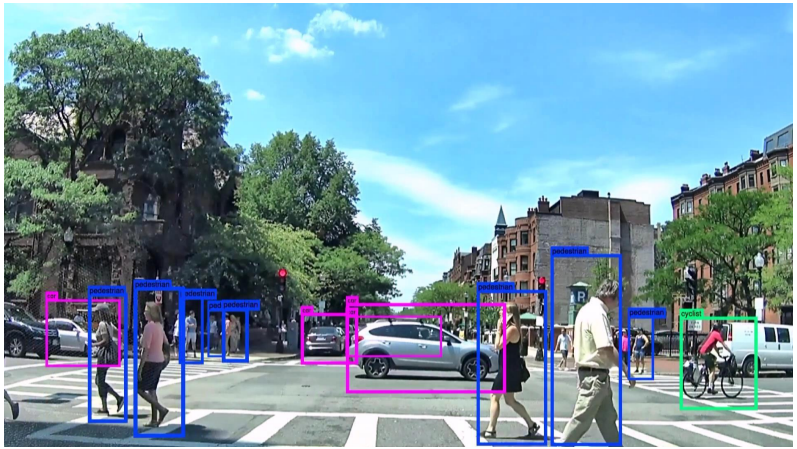
- PyCon Japan 2017 (last year!)
- PyCon Indonesia 2017
- PyCon Malaysia 2018

Iskandar Setiadi

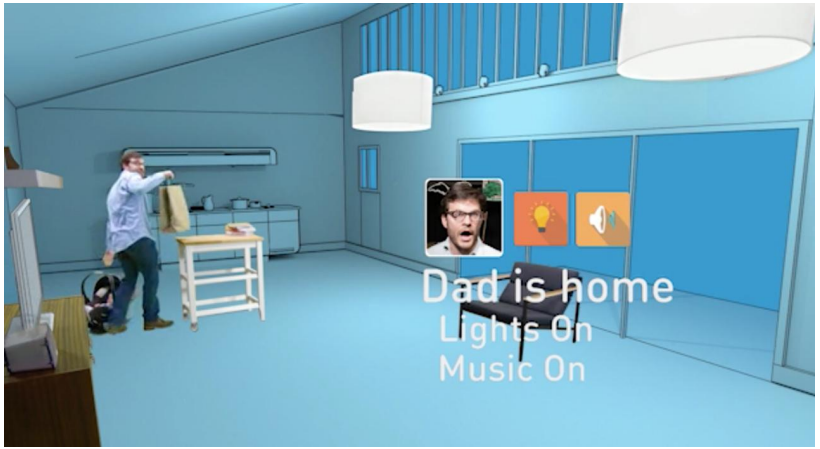
From Jakarta, Indonesia
Software Engineer at Japan

HDE, Inc. (https://hde.co.jp/en/)

Image Recognition in Real Life

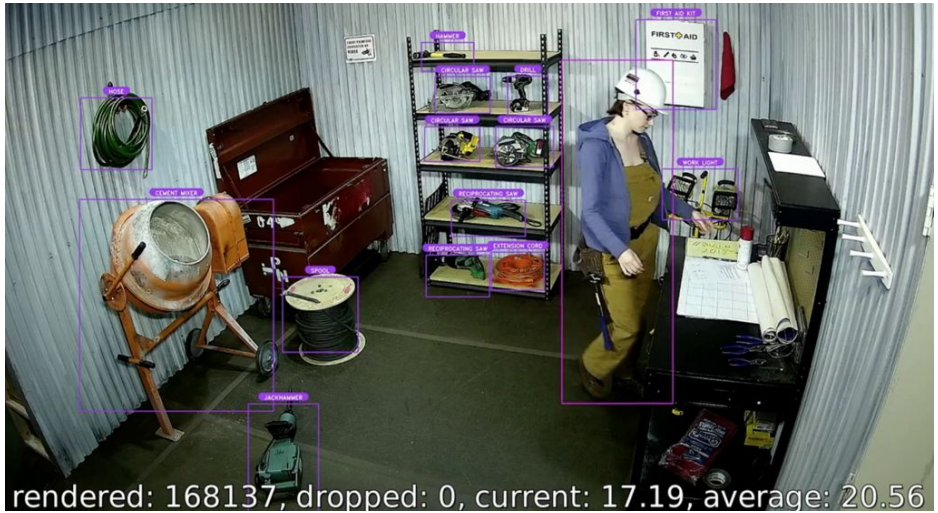


Self-driving car

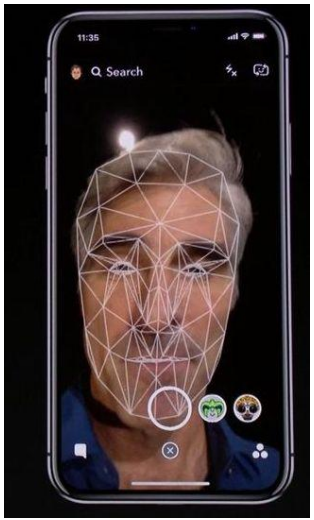


Smart home

Image Recognition in Daily Life



Smart workplace

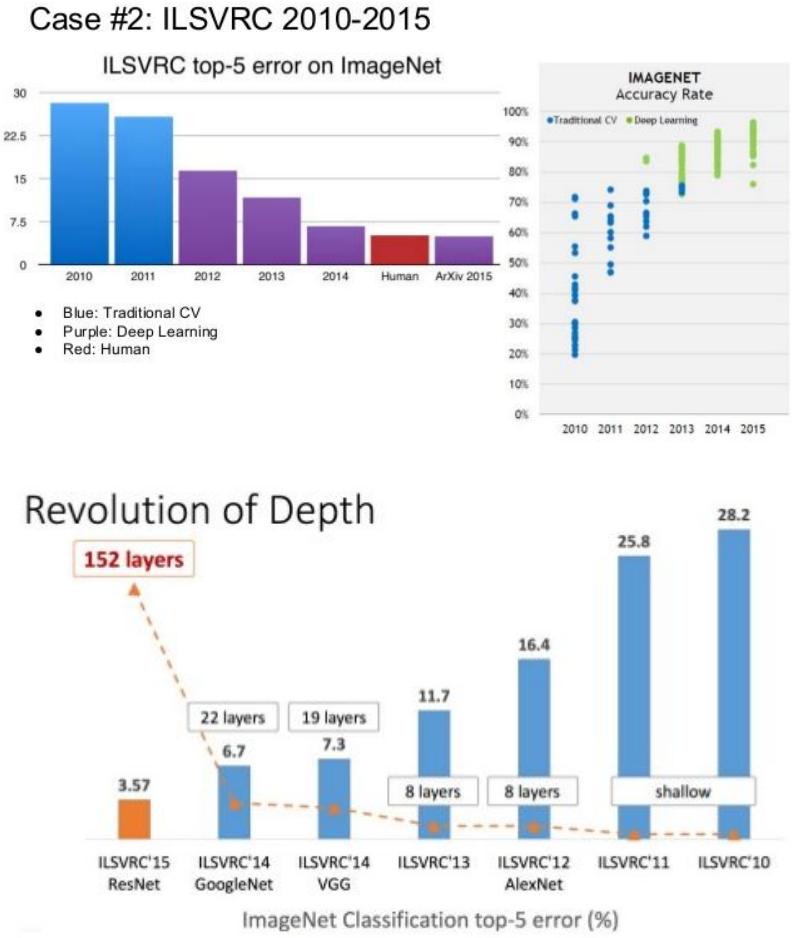


Face ID

ILSVRC

Largest Computer Vision Competition

Starting from 2015, deep learning has better top-5 error score compared to human (1000 categories)!



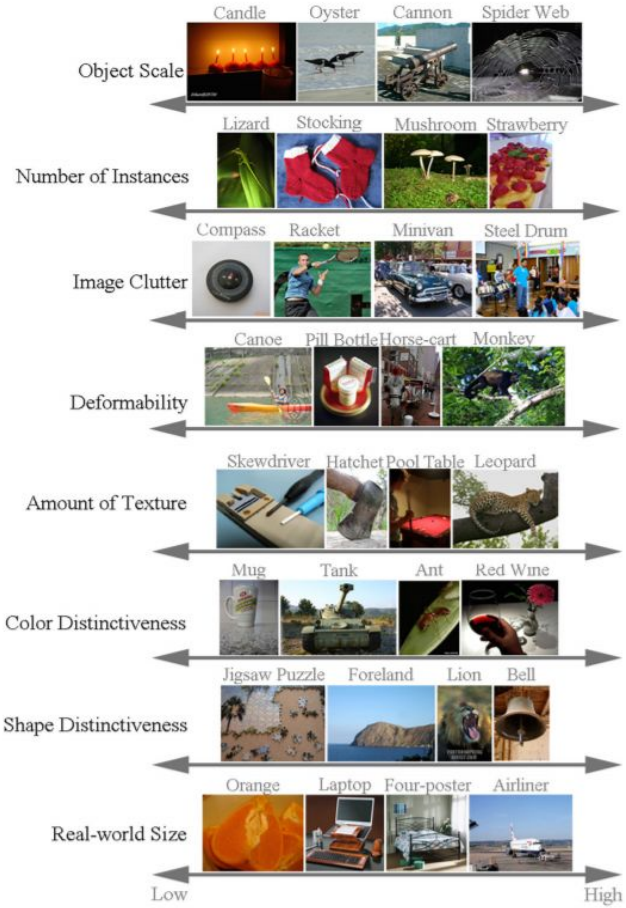
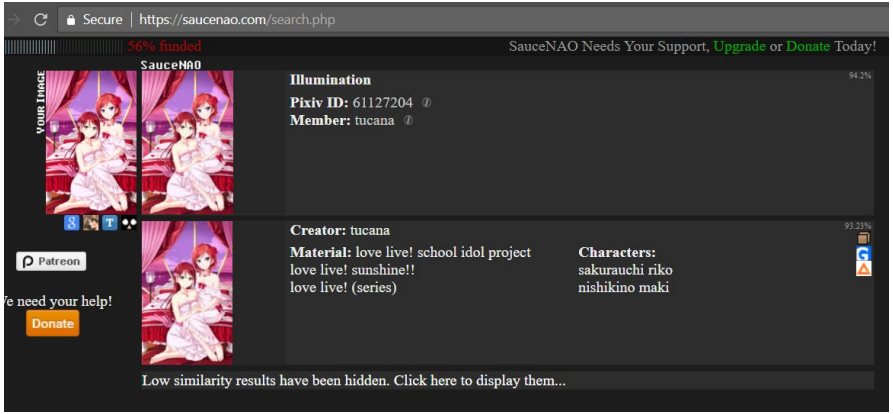


Image Recognition Challenges

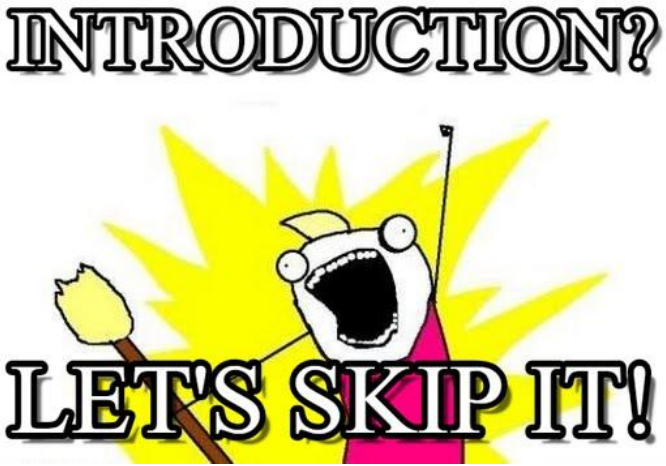
Background

Problem

- Cropped images
- Edited images
- Unindexed images



What is Machine Learning?



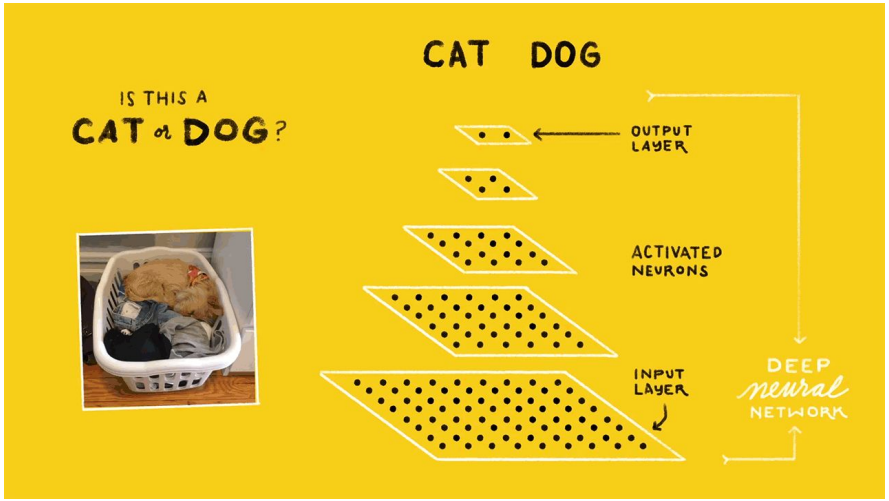
Deep Learning

Traditional ML:

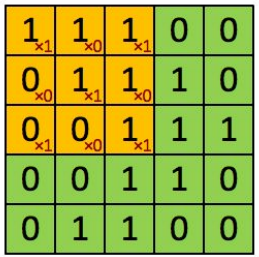
Increasing number of training iterations will eventually get stagnated at certain point.

Alternative proposal:

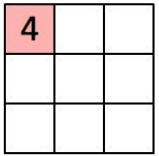
More layers! But it is slow :(



Deep Learning: Convolution



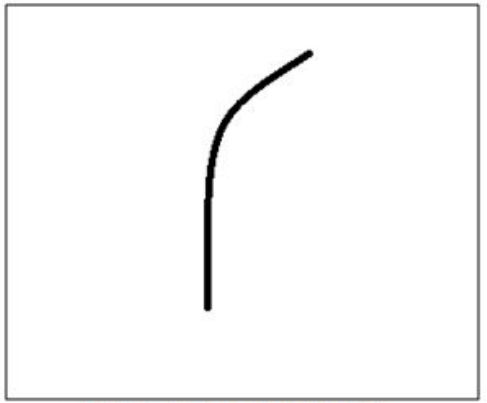
Image



Convolved Feature

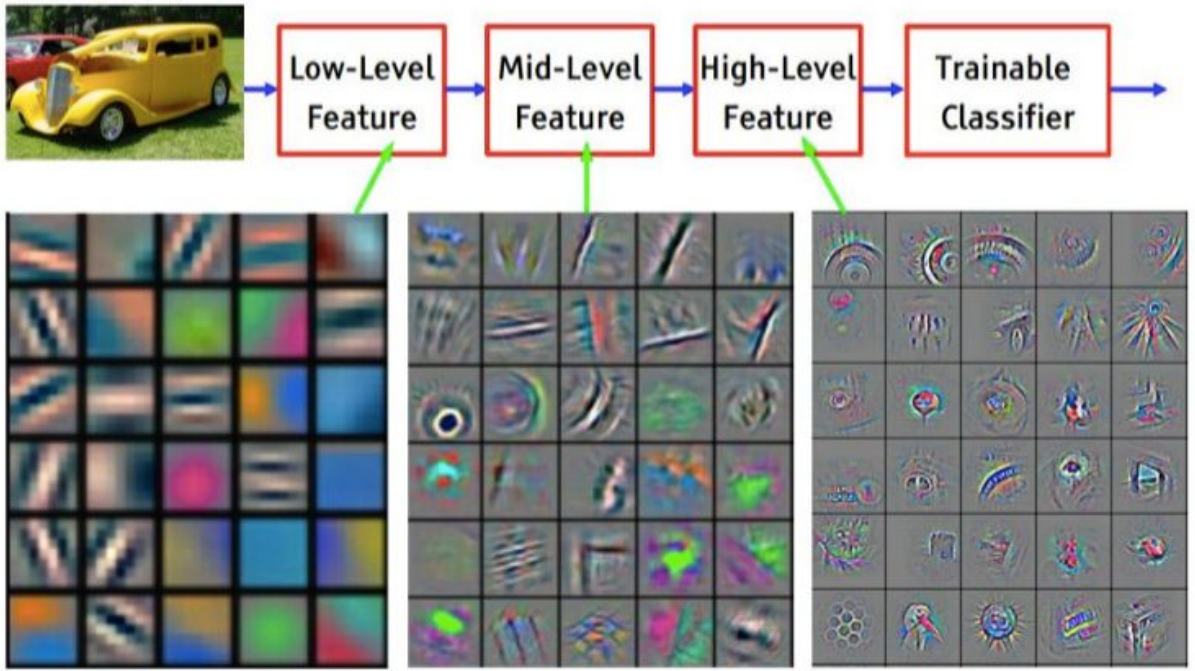
0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter



Visualization of a curve detector filter

Deep Learning



Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

Step 1. Preparation

TensorFlow Installation

```
$ pip3 install --upgrade tensorflow
```

or

```
$ pip3 install --upgrade tensorflow-gpu
```

URL: https://www.tensorflow.org/install/

Why should we use Transfer Learning?

From certain Top-5 characters indexing website:

- 35000 registered characters
- Top 1000 characters: 70+ images
- Top 2000 characters: 40+ images

Dataset size is small! Google Inception-v3 uses > 1000 images per category.

With transfer learning, we don't need to retrain low-level features extraction model.

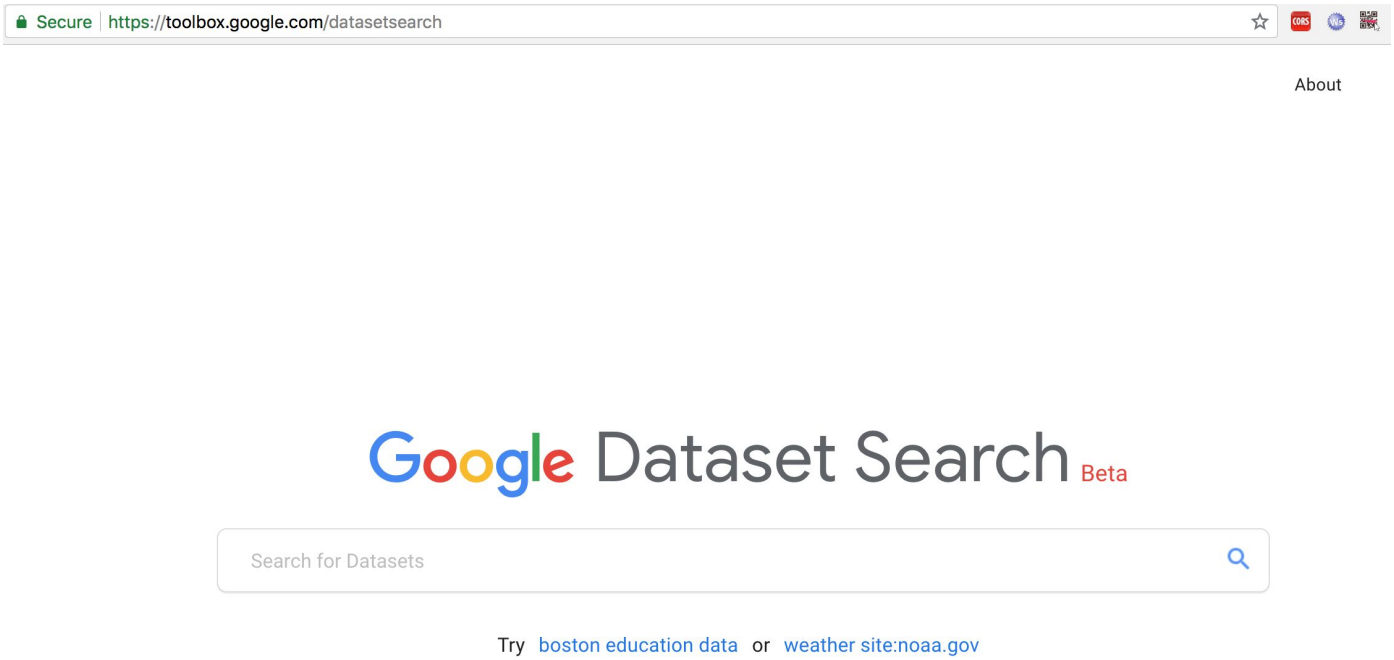
Result: **100 categories, ~ 60 images per category**.

URL: https://www.tensorflow.org/tutorials/image_retraining

Scrap & clean up the data

Note: Please contact me if you want to know the details

Google Dataset Search (Beta)



Google Dataset Search

anime character

About

Feec

kaggle Tagged Anime Illustrations
www.kaggle.com
Updated Jul 30, 2018

kaggle Anime Recommendations Database
www.kaggle.com
Updated Dec 21, 2016

kaggle The Simpsons Characters Data
www.kaggle.com
Updated Apr 13, 2018

V ArtiosCAD Workspace File
vistablog.com.ua

Danbooru2017: A large-scale crowdsourced and tagged anime illustration dataset

The first set of data comes from the imageboard Danbooru. The entire corpus of Danbooru images was scraped from the site with permission and was collected into a dataset. The zip files included here have the full metadata for these images as well as a subset of 300,000 of the images in normalized 512px x 512px form. Full information about this dataset is available here:

https://www.gwern.net/Danbooru2017

From the article:

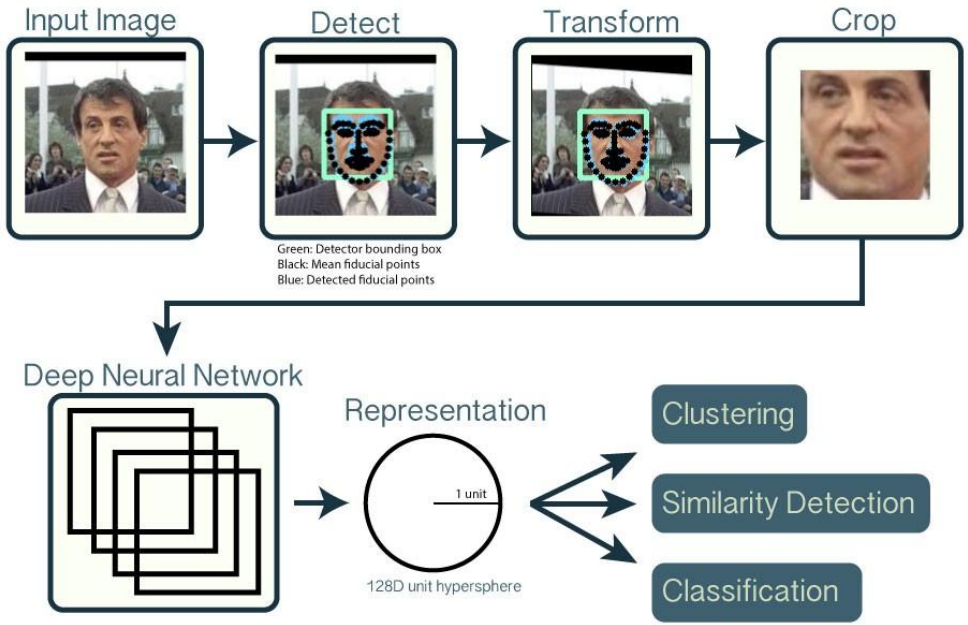
Deep learning for computer revision relies on large annotated datasets. Classification/categorization has benefited from the creation of ImageNet, which classifies 1m photos into 1000 categories. But classification/categorization is a coarse description of an image which limits application of classifiers, and there is no comparably large dataset of images with many tags or labels which would allow learning and detecting much richer information about images. Such a dataset would ideally be >1m images with at least 10 descriptive tags each which can be publicly distributed to all interested researchers, hobbyists, and organizations. There are currently no such public datasets, as ImageNet, Birds, Flowers, and MS COCO fall short either on image or tag count or restricted distribution. I suggest that the image-boorus be used. The image boorus are longstanding web databases which host large numbers of images which can be tagged or labeled with an arbitrary number of textual descriptions; they were developed for and are most popular among fans of anime, who provide detailed annotations.

The best known booru, with a focus on quality, is Danbooru. We create & provide a torrent which contains ~1.9tb of 2.94m images with 77.5m tag instances (of 333k defined tags, ~26.3/image) covering Danbooru from 24 May 2005 through 31 December 2017 (final ID: #2,973,532), providing the image files & a JSON export of the metadata. We also provide a smaller torrent of SFW images downscaled to 512x512px JPG (241GB; 2,232,462 images) for convenience.

Our hope is that a Danbooru2017 dataset can be used for rich large-scale classification/tagging & learned embeddings, test out the transferability of existing computer vision techniques (primarily developed using photographs) to illustration/anime-style images, provide an archival backup for the Danbooru community, feed back metadata improvements & corrections, and serve as a testbed for advanced techniques such as conditional image generation or style transfer.

Step 2. Analyze the Problem

Face Detection: Introduction



Face Detection (Human Face)

Adapted from https://github.com/shantnu/FaceDetect:

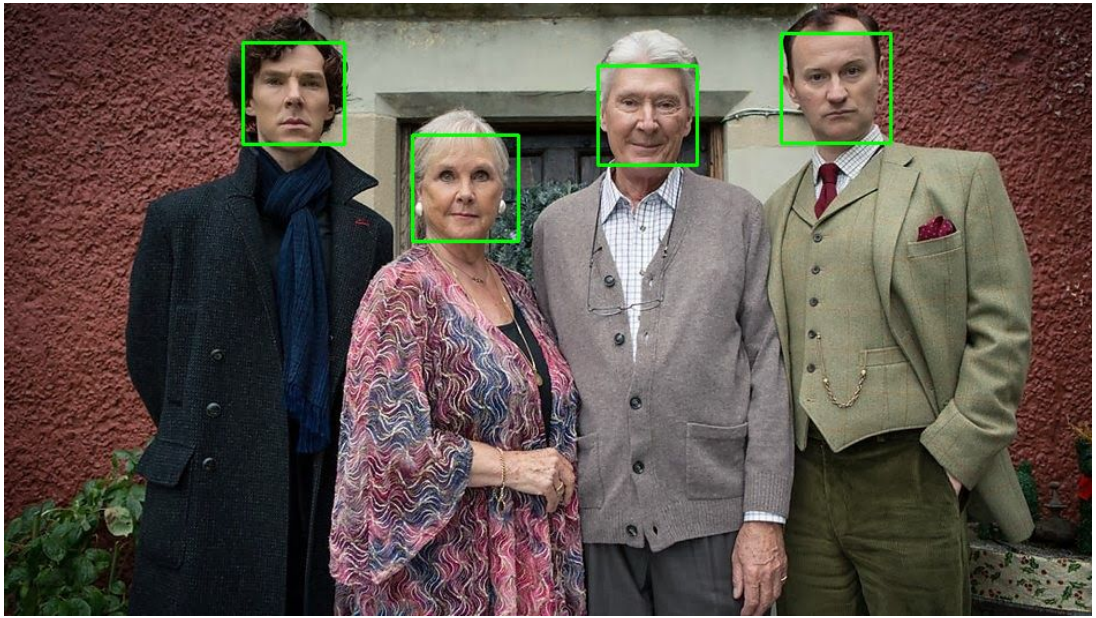
```
import cv2


faceCascade = cv2.CascadeClassifier("haarcascade_frontalface_default.xml")

image = cv2.imread(imagePath)
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

faces = faceCascade.detectMultiScale(gray, scaleFactor=1.1,
                                     minNeighbors=5, minSize=(30, 30))
```

Face Detection (Human Face)

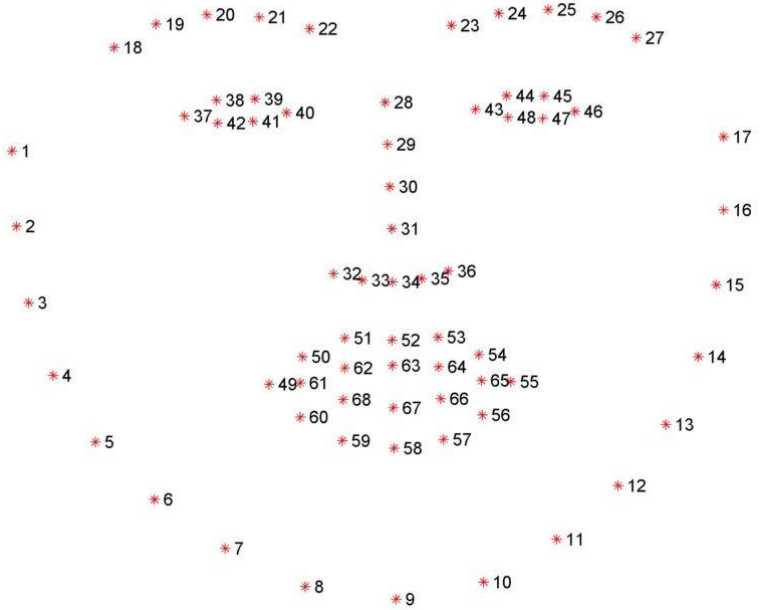


Face Detection (Same Model - Anime Face)

2D is ~~Better~~ not equal to 3D face!

Facial features are different!

e.g.: 2D has no nose



Face Detection: Train New Model!

Adapted from https://github.com/nagadomi/lbpcascade_animeface:

```
import cv2


cascade = cv2.CascadeClassifier("lbpcascade_animeface.xml")

image = cv2.imread(imagePath)
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

faces = cascade.detectMultiScale(gray, scaleFactor=1.1,
                                 minNeighbors=5, minSize=(24, 24))
```

Face Detection (Anime Face)

Face Detection (Same Model - Human Face)

Face Recognition

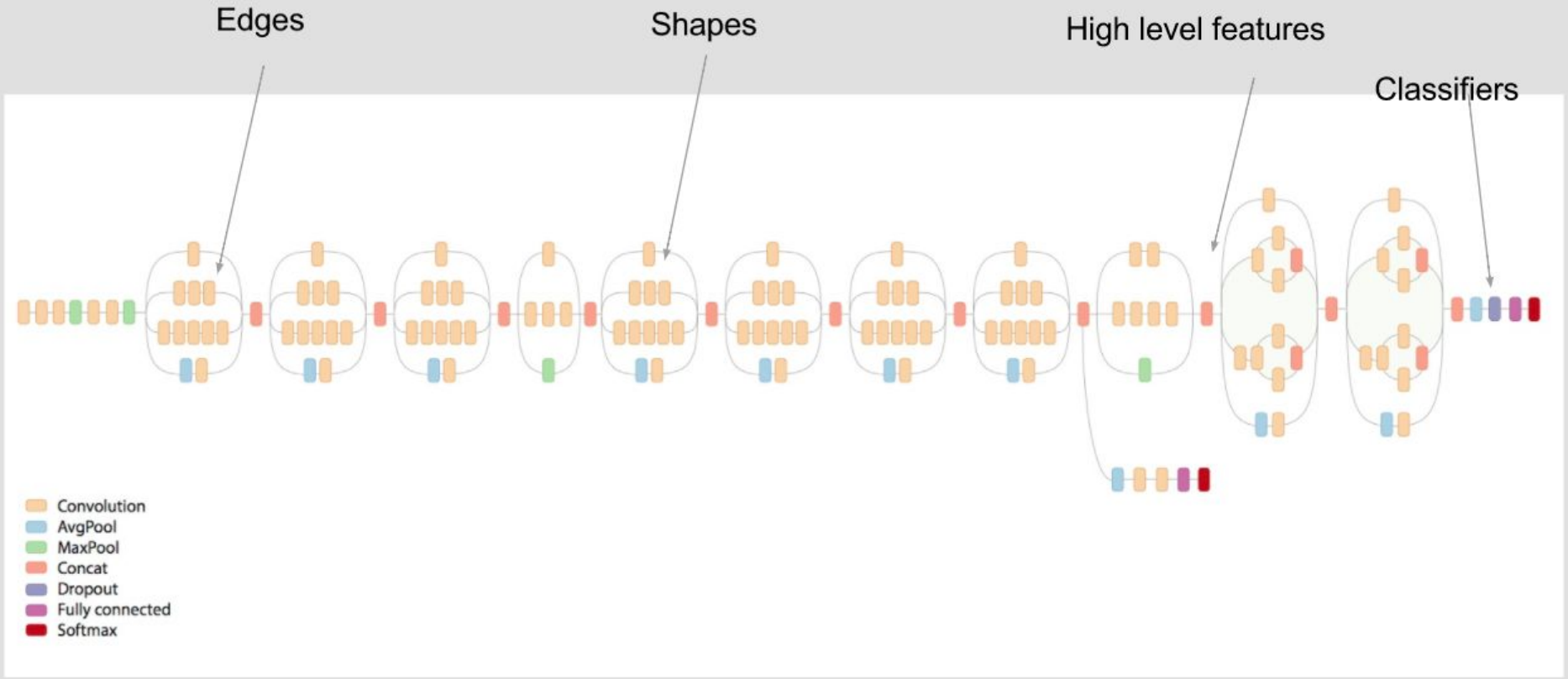
Face Detection → “Accomplished”

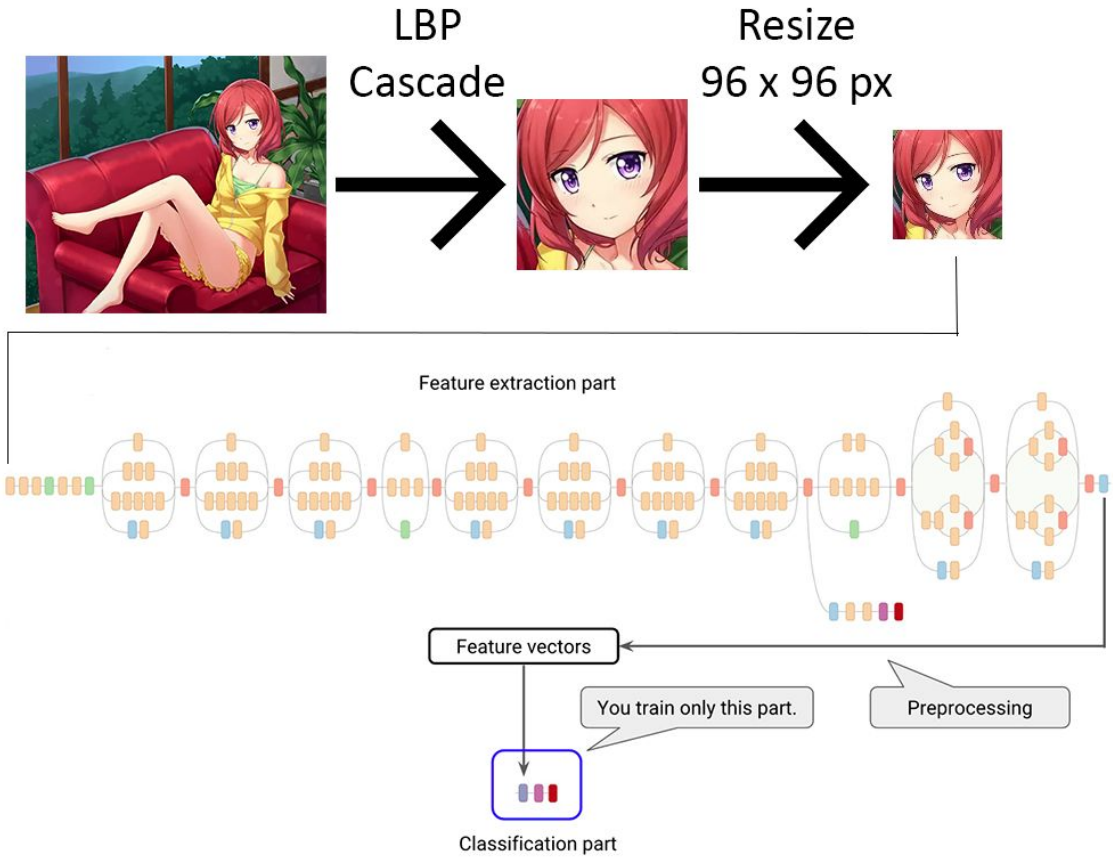
Full-layered Deep Learning → Requires a huge dataset, weeks to train

Google Inception-v3: 1.2 million training data, 1000 classes, 1 week to train

Step 3. Train & Validate the Model

What does the layers learn?




LBP
Cascade
Resize
96 x 96 px
Feature extraction part
Feature vectors
You train only this part.
Preprocessing
Classification part

Transfer Learning: Retrained Layers

Dropout: Dropping out units to prevent overfitting

Fully Connected: Extracting global features, every node in the layer is connected to the preceding layer

Softmax: Squashing final layer to make a prediction, which sums up to 1. For example, if we have 2 classes and class A has the value of 0.95, then class B will have the value of 0.05.

Transfer Learning: Retrain Final Layer

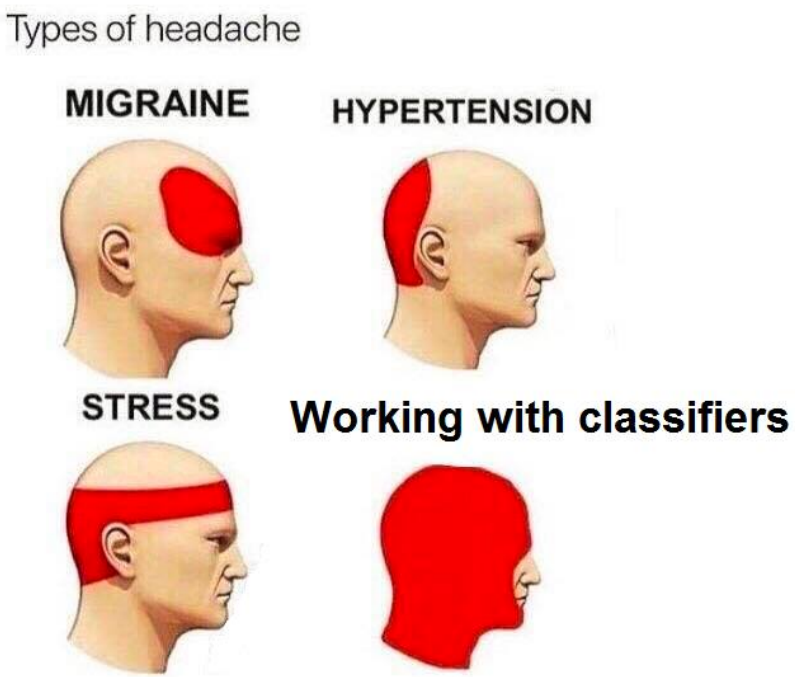
Build the retrainer:

```
$ bazel build tensorflow/examples/image_retraining:retrain
```

Execute the retrainer:

```
$ bazel-bin/tensorflow/examples/image_retraining/retrain --image_dir ~/images
```

Hyperparameters: learning rate, number of iterations, distortions factor, ...


Types of headache
MIGRAINE
HYPERTENSION
STRESS
Working with classifiers

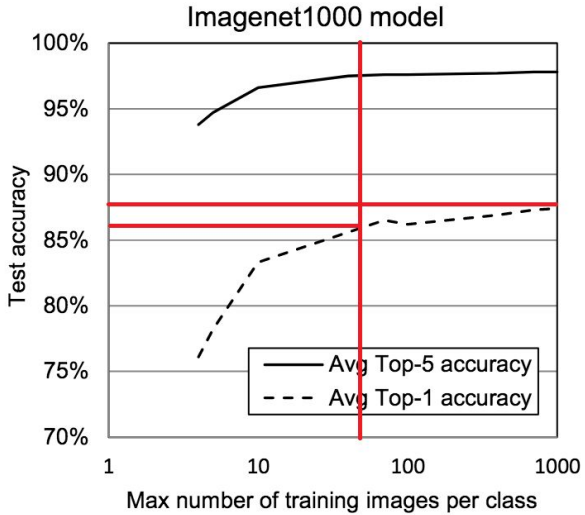
Original ImageNet: Accuracy vs Dataset size

From 10 to 100 training images per class, you can improve your Top-1 accuracy by 5%.

From 100 to 1000 training images per class, you can only improve it by less than 2%.

Low number of images → bad accuracy

Huge number of images → stagnated accuracy



URL: https://annals-csis.org/Volume_12/drp/pdf/526.pdf

Step 4. Serve as a Web App

MoeFlow: Specification

→ Build with Sanic (Flask-like Python 3.5+ web server); **Caveat**: Good for prototyping, have some memory handling issues

→ While training model requires huge GPU resources (g2.2xlarge), using retrained model can be hosted in server with small resources (t2.small)

What it does:

- Run face detection with OpenCV

- Resize image to a fixed proportion

- Run classification with TensorFlow

MoeFlow: Web App

```
@app.listener('before_server_start')
async def initialize(app, loop):
    moeflow_path = os.environ.get('MOEFLOW_MODEL_PATH')
    label_path = os.path.join(os.sep, moeflow_path, "output_labels_2.txt")
    model_path = os.path.join(os.sep, moeflow_path, "output_graph_2.pb")
    app.label_lines = [
        line.strip() for line in tf.gfile.GFile(label_path)
    ]
    graph = tf.Graph()
    graph_def = tf.GraphDef()
    with tf.gfile.FastGFile(model_path, 'rb') as f:
        graph_def.ParseFromString(f.read())
    with graph.as_default():
        tf.import_graph_def(graph_def, name='')
    app.graph = graph
    logging.info("MoeFlow model is now initialized!")
```

URL: https://github.com/freedomofkeima/MoeFlow

```
def classify_resized_face(file_name, label_lines, graph):
    results = []
    logging.info('Processing classification')
    with tf.Session(graph=graph) as sess:
        # Feed the image data as input to the graph and get first prediction
        softmax_tensor = sess.graph.get_tensor_by_name('final_result:0')
        input_operation = sess.graph.get_operation_by_name("Mul")
        t = read_tensor_from_image_file(file_name)
        predictions = sess.run(
            softmax_tensor,
            {input_operation.outputs[0]: t}
        )
        # Sort to show labels of first prediction in order of confidence
        top_k = predictions[0].argsort()[-3:][::-1]

        for node_id in top_k:
            human_string = label_lines[node_id]
            score = predictions[0][node_id]
            results.append((human_string, score))
    return results
```

MoeFlow: Use Retrained Model

```
2017-12-06 01:51:53 - (network)[INFO][127.0.0.1:49154]: GET http://127.0.0.1:888
8/static/images/83a97094d7634333b5c9d7e8e0901da4.jpg  200 119582
INFO:network:
2017-12-06 01:51:53 - (network)[INFO][127.0.0.1:49156]: GET http://127.0.0.1:888
8/static/images/e96410fcf8114fbb88a4f33ede40205e.jpg  200 5902
INFO:network:
2017-12-06 05:48:33 - (network)[INFO][127.0.0.1:59920]: GET http://127.0.0.1:888
8/  200 1180
INFO:network:
INFO:root:Height: 1416, Width: 1280
INFO:root:Input file is created at /tmp/tmpgm8odxy2.jpg
INFO:root:Processing classification
INFO:root:[('tedeza rize', 0.8941825), ('yui', 0.015284972), ('takanashi rikka',
 0.014930859)]
2017-12-06 05:49:38 - (network)[INFO][127.0.0.1:59970]: POST http://127.0.0.1:88
88/  200 1565
INFO:network:
2017-12-06 05:49:39 - (network)[INFO][127.0.0.1:59972]: GET http://127.0.0.1:888
8/static/images/fda2e4333b194f30a845ed8d320bf449.jpg  200 294605
INFO:network:
2017-12-06 05:49:39 - (network)[INFO][127.0.0.1:59974]: GET http://127.0.0.1:888
8/static/images/d9a530d76c17404fbdbde7a2e5bf9c55.jpg  200 5807
INFO:network:
```

MoeFlow: Use Retrained Model

Demo

Input:

Output:

Character	Prediction (Top-3)
	• kafuu chino • miki sayaka • kashima

Input:

Output:

Character	Prediction (Top-3)
	• jouga maya • hyoudou michiru • ujimatsu chiya
	• kafuu chino • izumi sagiri • aqua
	• natsu megumi • yoshino • inokuma youko

Results / Demo

Input:

Output:

Character	Prediction (Top-3)
	• suzukaze aoba • kafuu chino • yamada elf
	• yagami kou • ayase eli • tomoe mami

Results / Demo

Other Projects / Alternatives

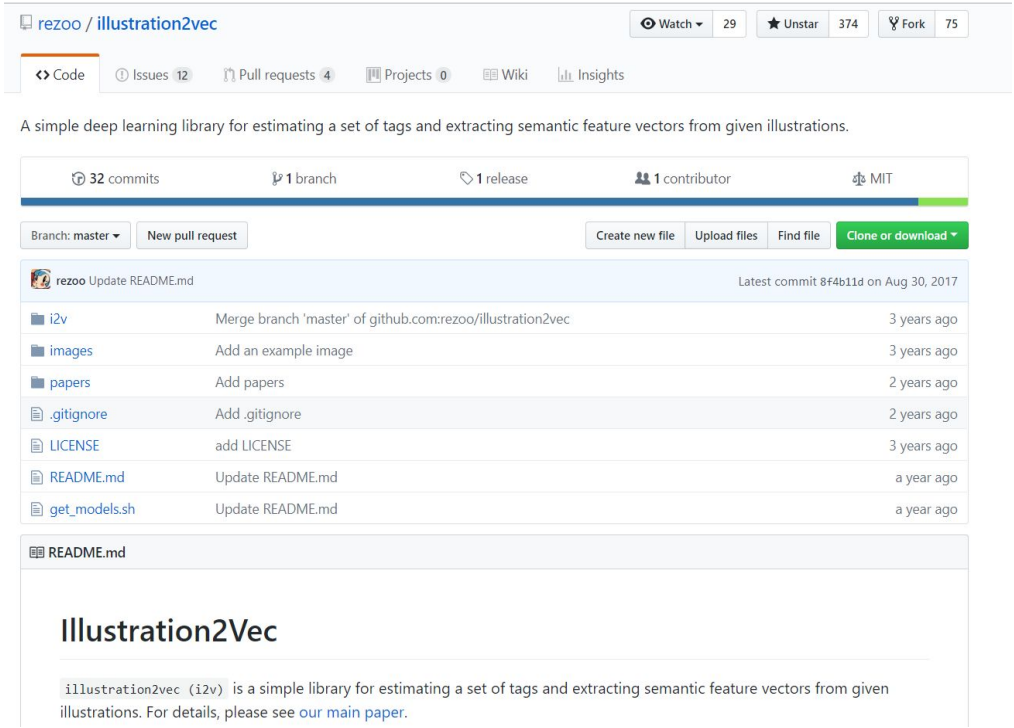
rezoo/illustration2vec

Semantic feature vectors.

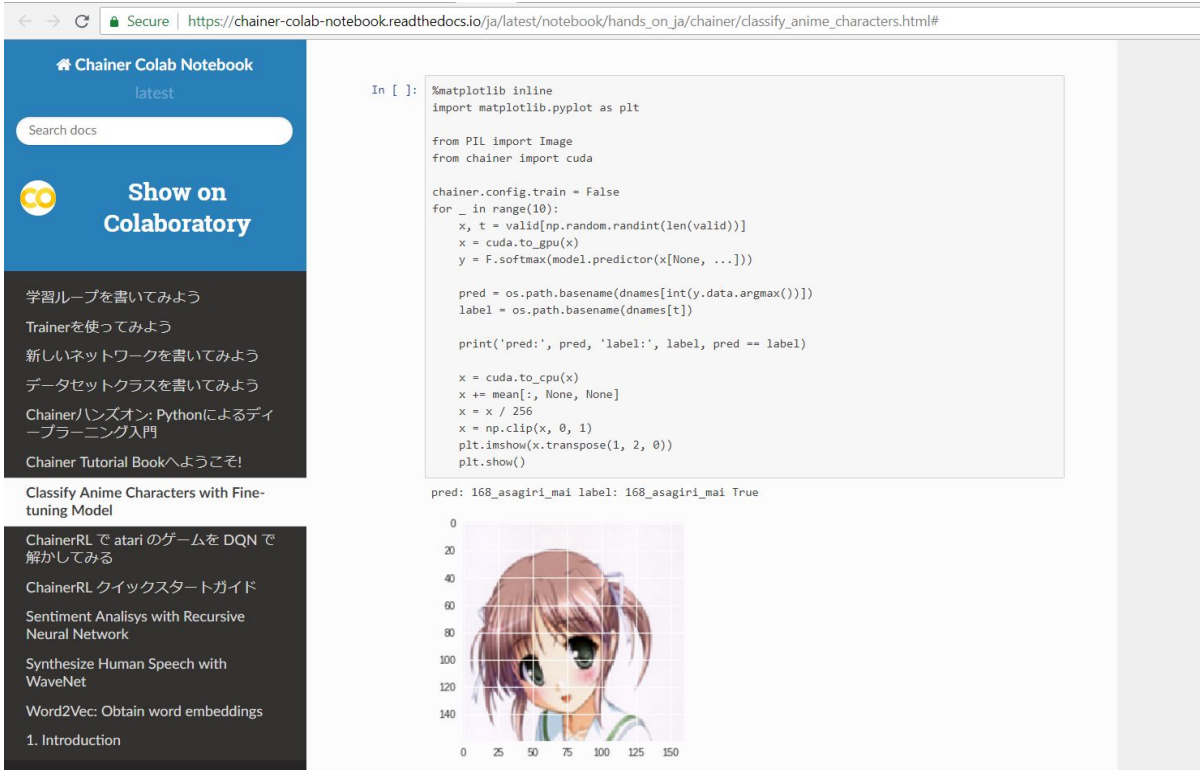
For example:

- Character

- General (hair color, eye color, etc)



Chainer + illustration2vec



PaaS - Platform as a Service

- Clarifai → since 2016

- Azure Custom Vision → Beta release as 2018

- Google Cloud AutoML → Beta release as 2018

Cloud AutoML Vision

Amazon Rekognition
Metrics

Demos
Object and scene detection
Image moderation
Facial analysis
Celebrity recognition
Face comparison
Text in image

Video Demos
Video analysis

Additional Resources
Getting started guide
Download SDKs
Developer resources
Pricing
FAQ
Forum

Face comparison

Compare faces to see how closely they match based on a similarity percentage.

InvalidParameterException (400)
Request has Invalid Parameters (Image must contain detectable faces)

Reference face

Choose a sample image

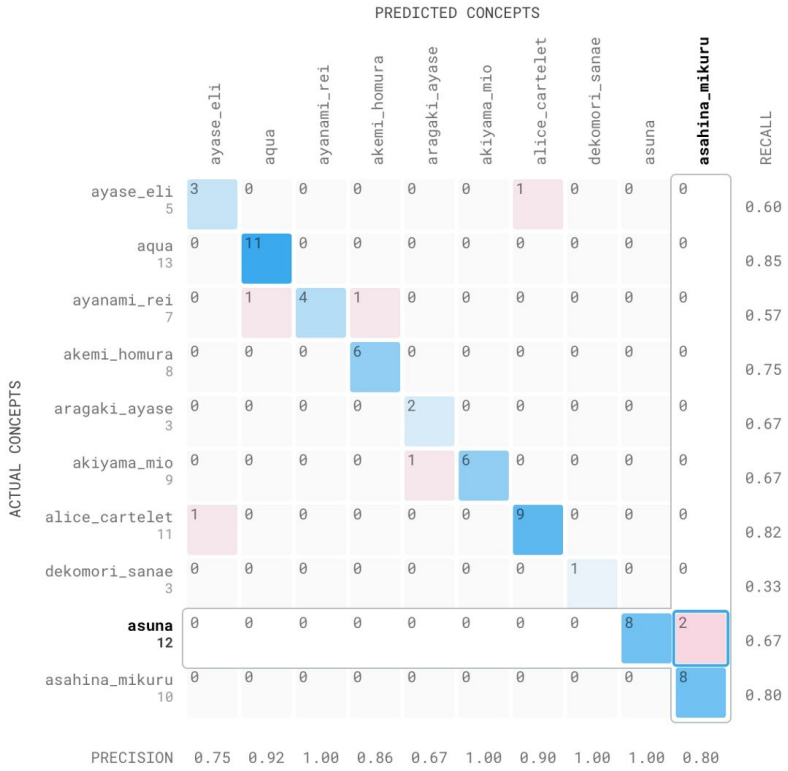
Comparison faces

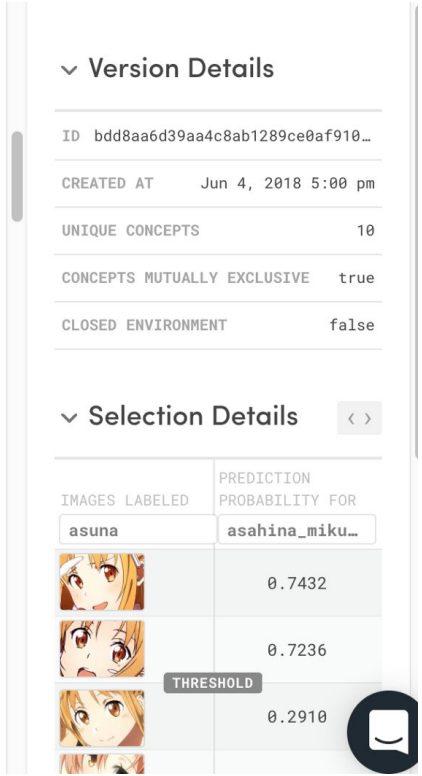
Choose a sample image

Done with the demo?
Learn more

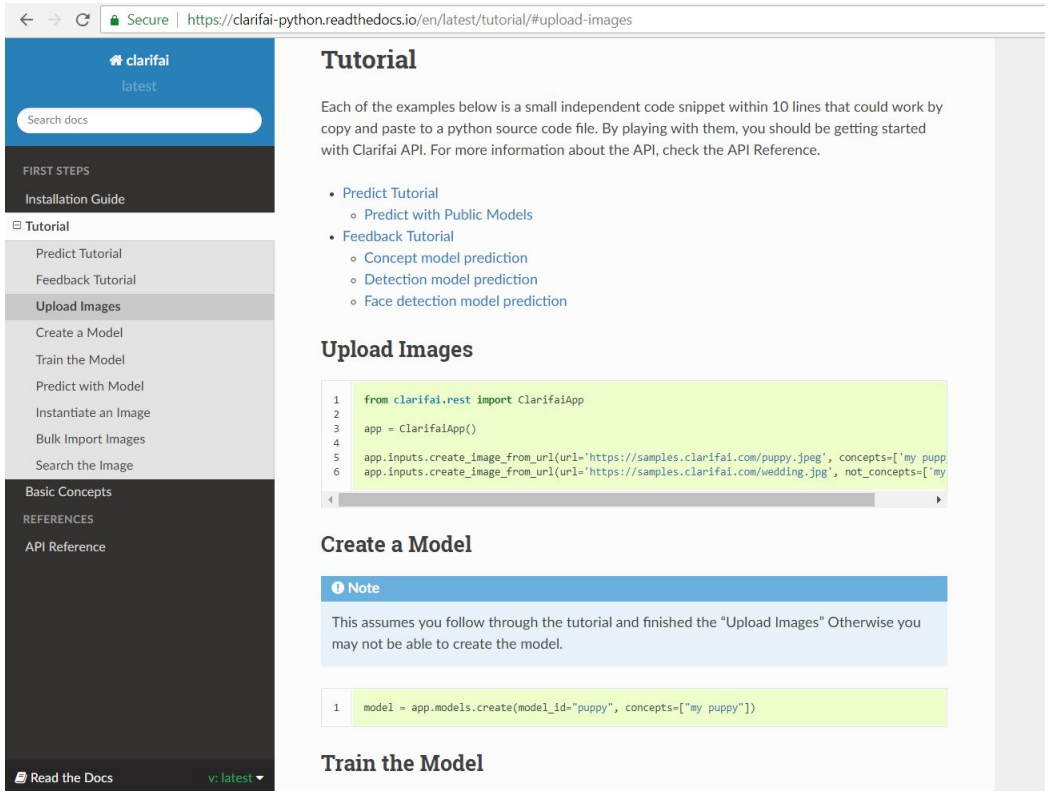
- Results
- Request
- Response

Clarifai UI

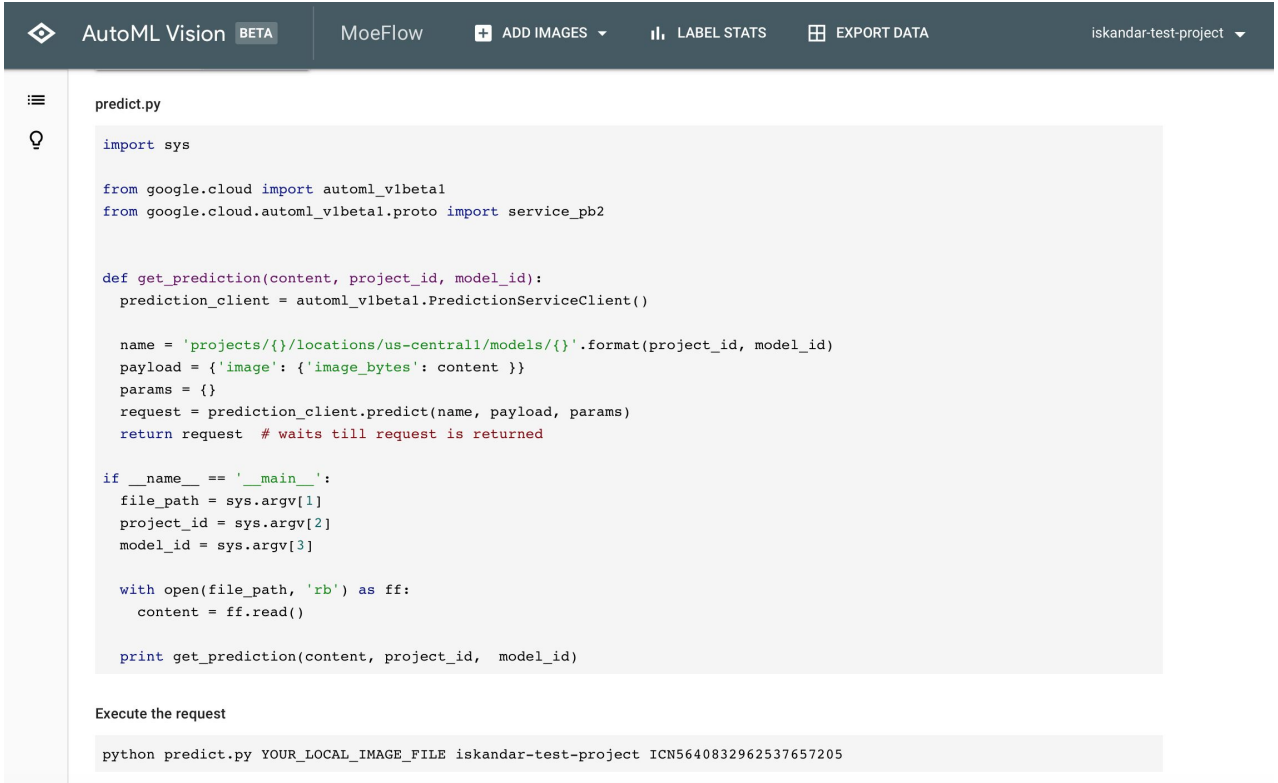

PREDICTED CONCEPTS
ayase_eli
aqua
ayanami_rei
akemi_homura
aragaki_ayase
akiyama_mio
alice_cartelet
dekomori_sanae
asuna
asahina_mikuru
RECALL
ACTUAL CONCEPTS
ayase_eli 5
aqua 13
ayanami_rei 7
akemi_homura 8
aragaki_ayase 3
akiyama_mio 9
alice_cartelet 11
dekomori_sanae 3
asuna 12
asahina_mikuru 10
0.60
0.85
0.57
0.75
0.67
0.67
0.82
0.33
0.67
0.80
PRECISION 0.75 0.92 1.00 0.86 0.67 1.00 0.90 1.00 1.00 0.80


Version Details
ID bdd8aa6d39aa4c8ab1289ce0af910…
CREATED AT Jun 4, 2018 5:00 pm
UNIQUE CONCEPTS 10
CONCEPTS MUTUALLY EXCLUSIVE true
CLOSED ENVIRONMENT false
Selection Details
IMAGES LABELED
PREDICTION PROBABILITY FOR
asuna
asahina_miku…
0.7432
0.7236
THRESHOLD
0.2910

Clarifai: Python API



Google Cloud AutoML: Python API



Quick Comparison (as August 2018)

Top-1 Accuracy with pre-processed model (after face detection, same dataset)

Clarifai → **95.2%** (they have been in this business for years)

Google Cloud AutoML → **93%** (their model is based on improved version of Inception v3, so it fails on almost the same test data)

MoeFlow (my model) → **88.6%** (let be fair, I'm not a machine learning expert and my job is unrelated to machine learning 😸, but at least it's free and I can put it together with my server!)

Azure Custom Vision → **77.4%** (at least it's better than Microsoft, but they are still in Beta)

Clarifai

Details

TRANSFER-LEARNING-ANIME PREDICT TRAIN

aragaki_ayase	0.59	dekomori_sanae	0.00
akemi_homura	0.25	asuna	0.00
ayanami_rei	0.06	ayase_eli	0.00
aqua	0.05	asahina_mikuru	0.00
akiyama_mio	0.04	alice_cartelet	0.00

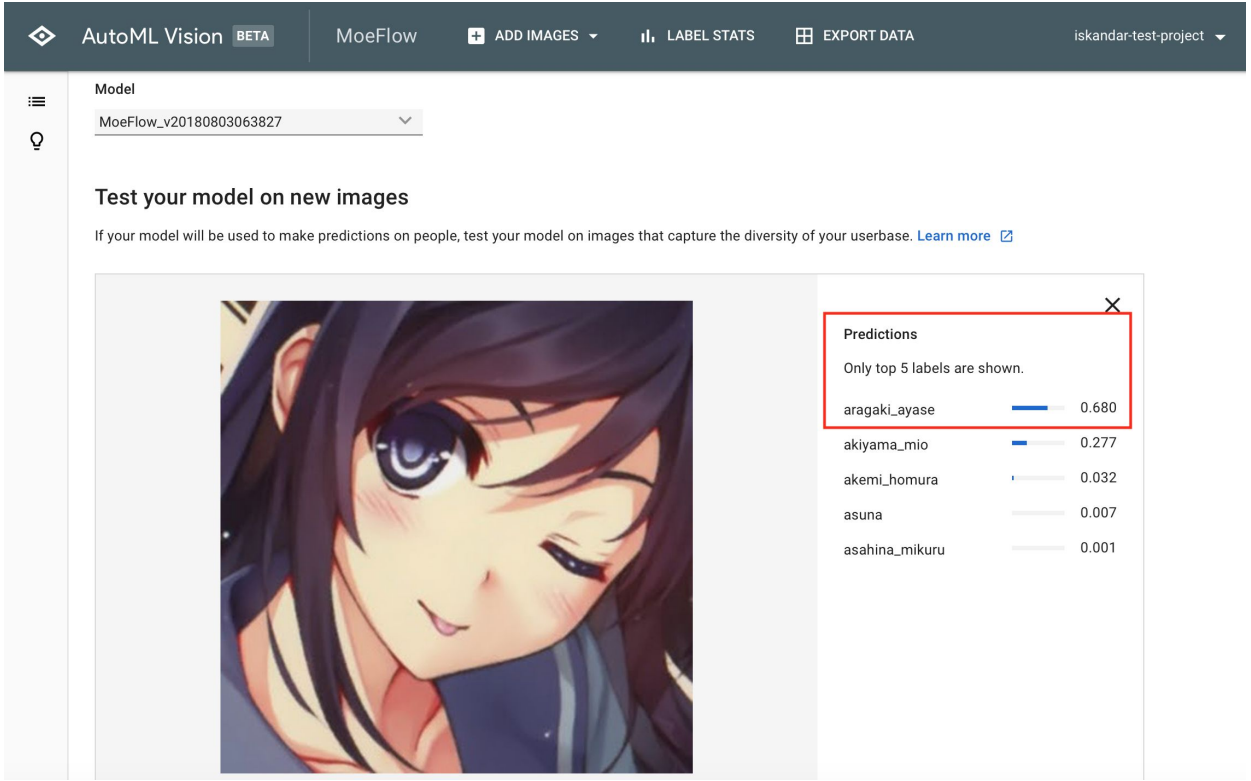
Create Concept

GENERAL-V1.3

GENERAL-V1.3

illustration	0.97	face	0.90
woman	0.96	man	0.90
fun	0.94	people	0.89
fashion	0.94	vector	0.89
young	0.93	music	0.88

Google Cloud AutoML



MoeFlow

Input:

Output:

Character	Prediction (Top-3)
	• aragaki ayase • hyoudou michiru • miki sayaka

```
Downloads — ec2-user@ip-172-31-48-241:~ — ec2-user@ip-172-31-48-241:~/
INFO:root:[('aragaki ayase', 0.54832304), ('hyoudou michiru', 0.21569832), ('mik
i sayaka', 0.079943478)]
2018-06-04 08:48:44 - (network)[INFO][127.0.0.1:58852]: POST http://127.0.0.1:88
88/  200 4226
INFO:network:
2018-06-04 08:48:44 - (network)[INFO][127.0.0.1:58854]: GET http://127.0.0.1:888
8/static/images/1b0201bd4c6941f0a4ec66617c290e5b.jpg  200 32458
INFO:network:
2018-06-04 08:48:45 - (network)[INFO][127.0.0.1:58856]: GET http://127.0.0.1:888
8/static/images/65a0f659c5734b69a27665dd56fe25b2.jpg  200 32458
INFO:network:
```

Azure Custom Vision

My Tags

aragaki_ayase

Predictions

Tag	Probability
aqua	11%
ayanami_rei	9.9%
akemi_homura	8.8%
akiyama_mio	6.3%
aragaki_ayase	5.7%
ayase_eli	2.1%
asuna	2%
asahina_mikuru	0.6%

When should we use PaaS for Image Recognition?

(+) Image recognition is not directly related to your main business and you don't want to invest too much time on it

(+) You don't need the capability of customizing training model

(+) You have money $$$, PaaS tends to get more expensive in the long run

(+) You are satisfied with the result, of course, you should compare all available PaaS out there, they have their own strong points

What to compare:

- Single vs multi-objects, e.g.: Car vs [Car, Ball, …]

- Single class vs multiple tags, e.g.: Car vs Toyota (Brand name), or [Vehicle: 0.99, Car: 0.97, …]

- Top-1 vs Top-x accuracy

- Cost

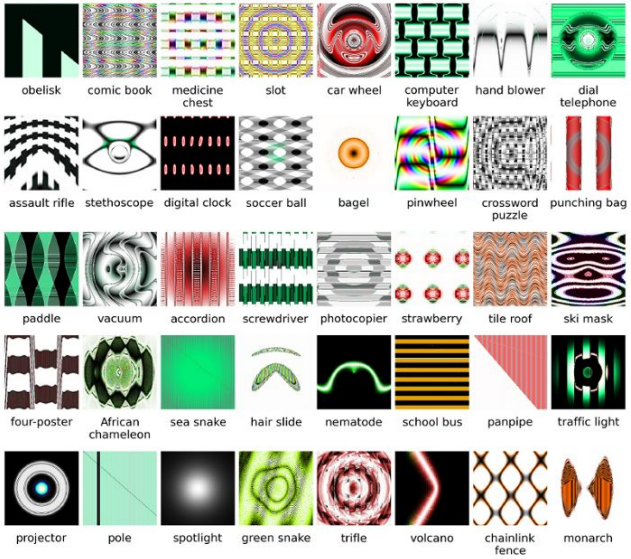
Closing Remarks

“Never-ending” Development

As the number of category increases, Top-1 accuracy will also decrease since some characters are too similar (free-style art) and transfer learning effect is diminished.

- Image noise
- Rotation / axis
- Face expressions (closed eyes, etc)
- Characters with “multiple” forms
- Brightness & Contrast

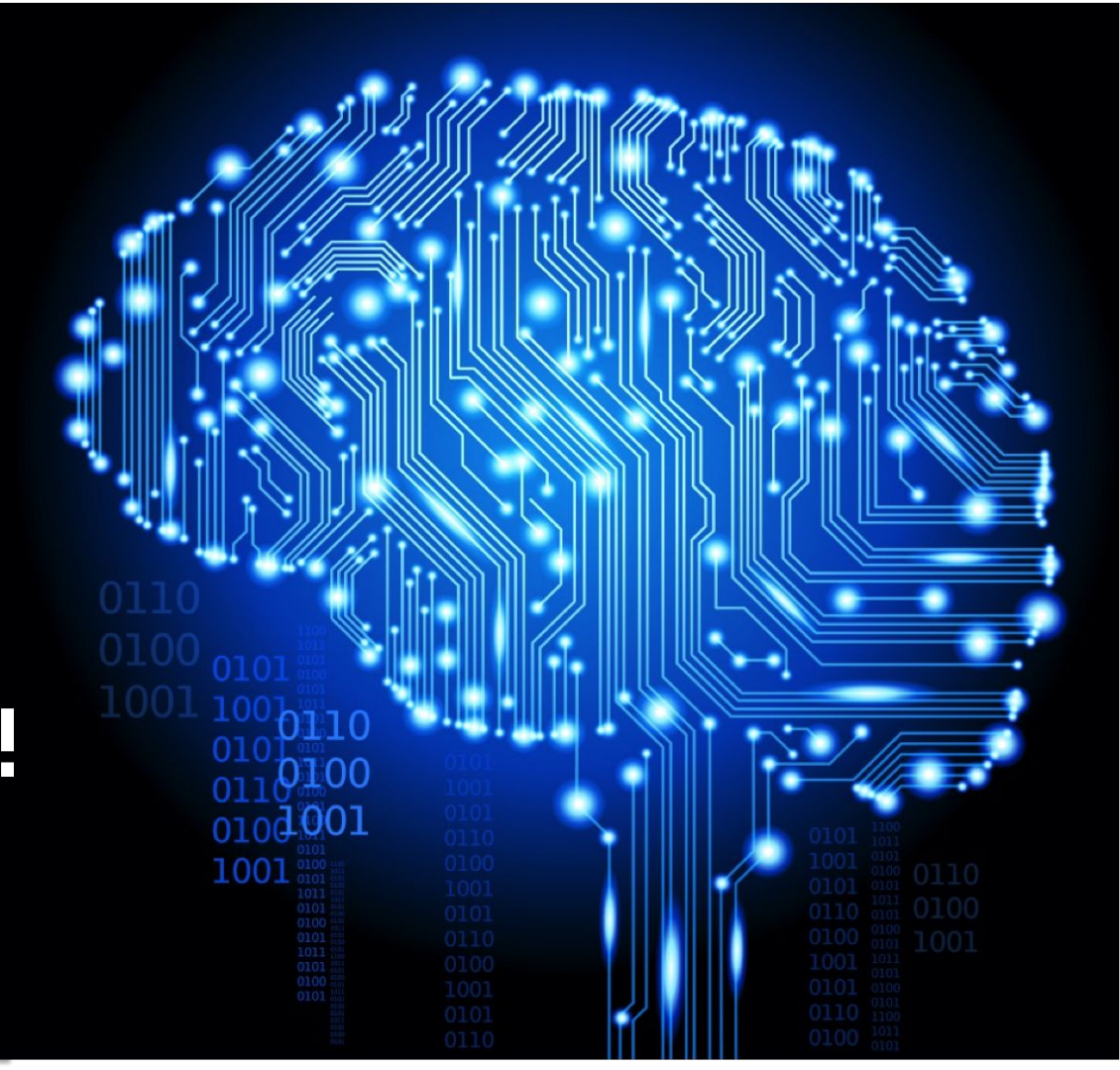
Fooling Neural Network



Original image
Output Label: **Teapot**

Noisy image (10% impulse noise)
Output Label: **Biology**

Generalizing Ideas - Solve Your Own Problems!



Github Projects

freedomofkeima/MoeFlow: Repository for anime characters recognition website (Alpha)

freedomofkeima/transfer-learning-anime: Transfer Learning for Anime Characters Recognition

freedomofkeima/opencv-playground: Compare 2D and 3D OpenCV Cascade Classifier

Presentation Slide

https://freedomofkeima.com/pyconjp2018.pdf

Curated List

https://github.com/kjw0612/awesome-deep-vision
http://www.themtank.org/a-year-in-computer-vision

HDE, Inc. at Shibuya, Tokyo

HDE
Liberation of Technology

Global Internship Program
https://www.hde.co.jp/en/gip/

PyCon JP 2018 Sprint Sponsor

Full-timer benefits: Get your CfP accepted and the company will handle the rest!


HDE
GLOBAL
INTERNSHIP
PROGRAM

Thank you!

freedomofkeima

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