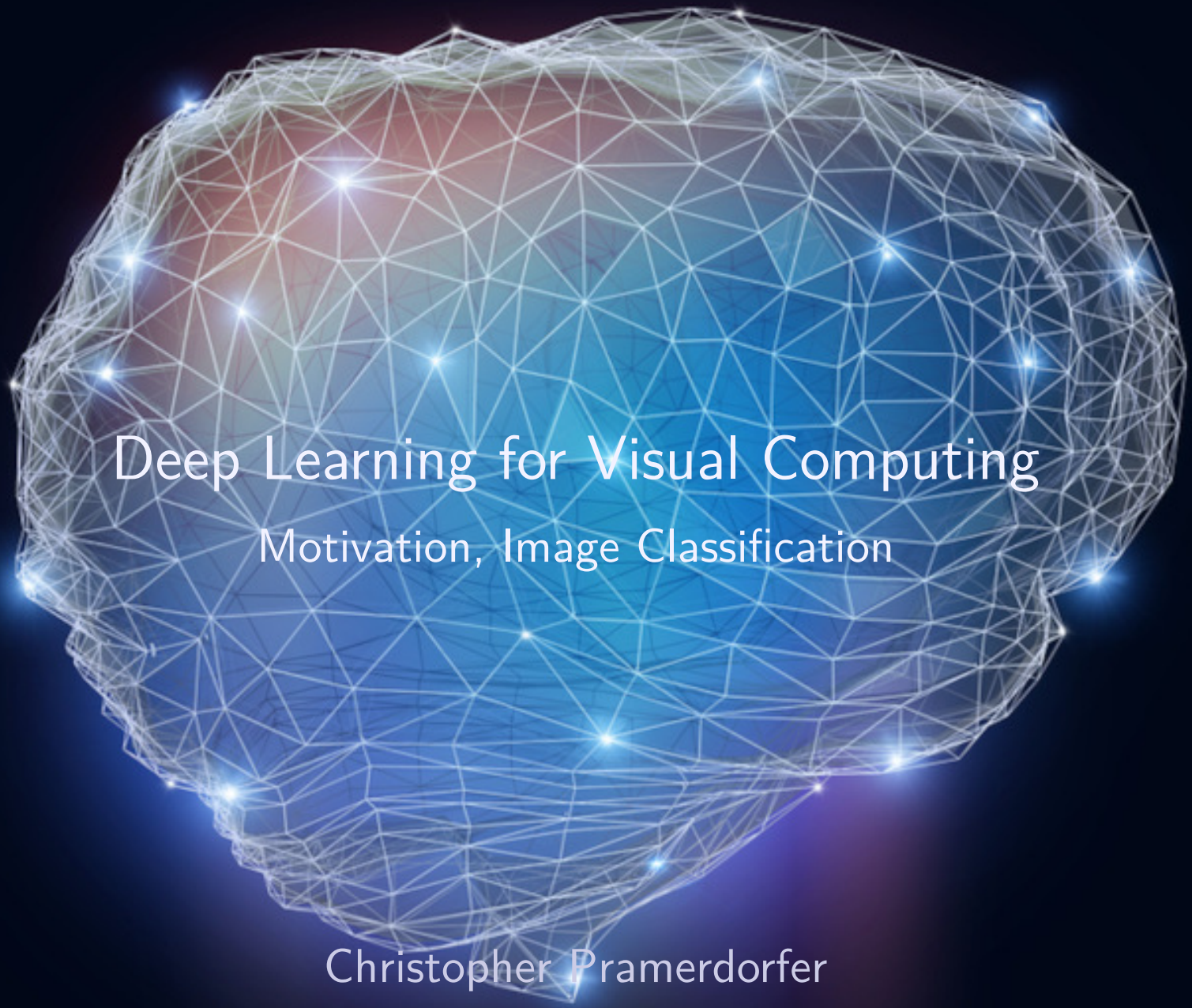

Deep Learning for Visual Computing

Motivation, Image Classification

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Computer Vision Lab, TU Wien

Image by Oracle

Topics

Motivation for Deep Learning

- Selection of applications

Image classification

- Challenges
- Datasets
- Manual approach

Motivation for Deep Learning

Course is called Deep Learning for Visual Computing

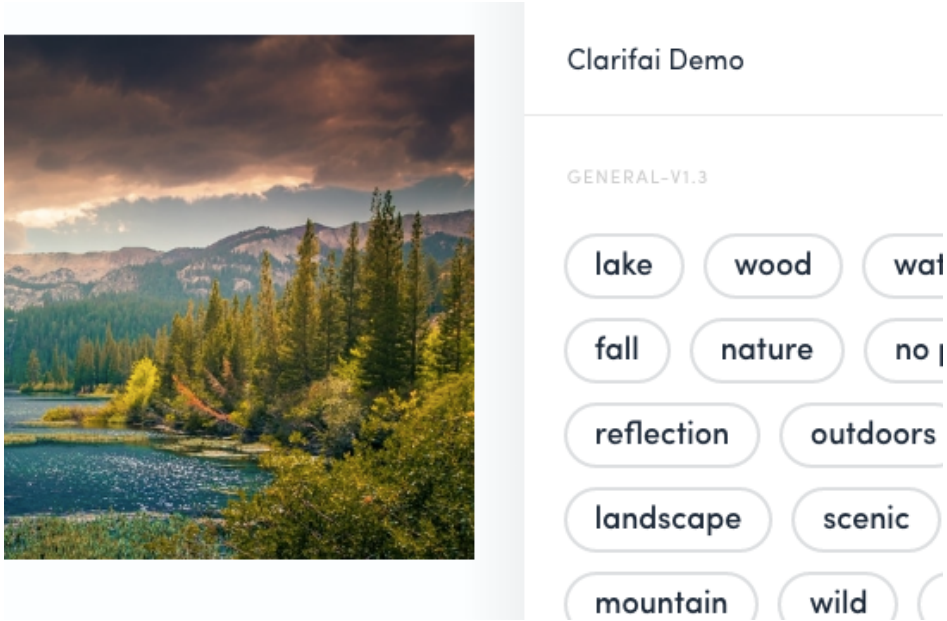
- Very generic term (includes computer graphics etc.)

We'll focus on Computer Vision

- Make computers gain high-level understanding of images
- Goal is human-like understanding

Motivation for Deep Learning

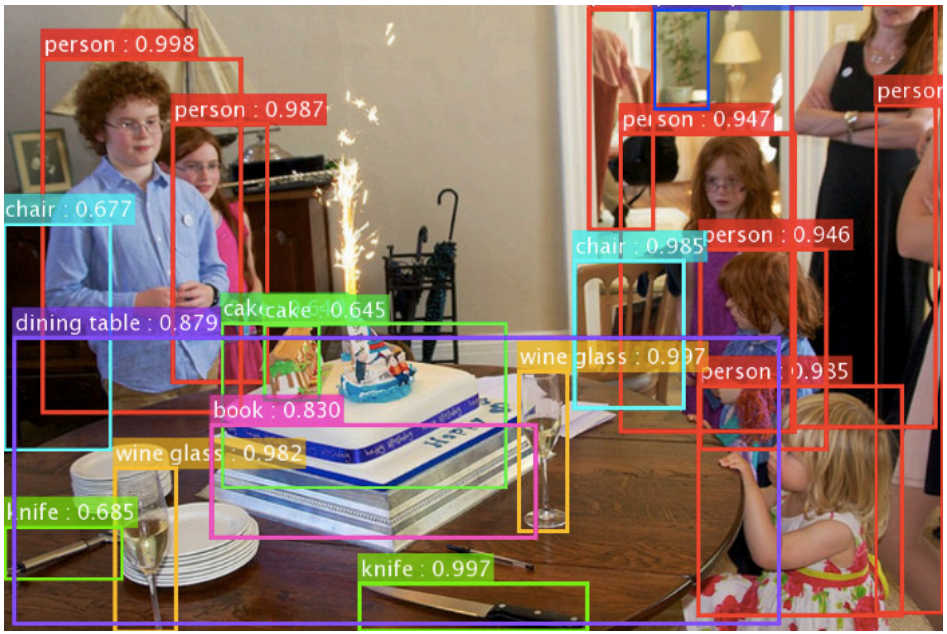
What high-level understanding means depends on problem



"Describe the image with keywords" – link

Motivation for Deep Learning

What high-level understanding means depends on problem



"Detect notable objects"

Motivation for Deep Learning

What high-level understanding means depends on problem

"Detect traffic participants" – link

Motivation for Deep Learning

What high-level understanding means depends on problem

"Be an artist" – link

Motivation for Deep Learning

What high-level understanding means depends on problem

"Estimate people's poses" – link

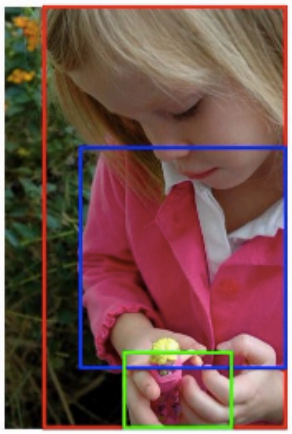
Motivation for Deep Learning

What high-level understanding means depends on problem

"Generate realistic videos" – link

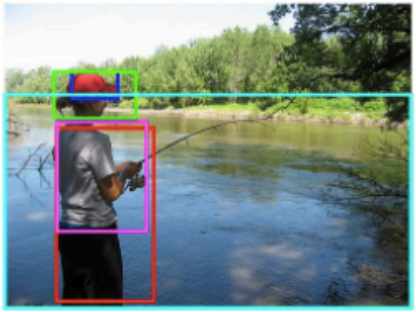
Motivation for Deep Learning

What high-level understanding means depends on problem



A little girl in a pink shirt is looking at a toy doll.

A woman is riding a bicycle on the pavement.



A girl with a red cap, hair tied up and a gray shirt is fishing in a calm lake.

"Describe the image with a sentence" – paper

Motivation for Deep Learning

All these examples are based on Deep Learning

- Would be impossible otherwise at this quality
- We will take a closer look throughout the lecture

Deep Learning is state of the art

- In virtually any Computer Vision task
- In other fields as well (e.g. speech recognition)

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Image Classification

Fundamental Computer Vision task

Definition

- Given a set of class labels (e.g. {bird, cat, dog})
- Which class does the given image belong to?

$\Rightarrow$ cat

Image from youtube.com

Image Classification

Image belongs to exactly one class in the set

- Comparatively easy task
- On some datasets Deep Learning outperforms humans

But still very challenging

Image Classification
Challenges – Pose and Viewpoint

Image adapted from warrenphotographic.co.uk

Image Classification
Challenges – Illumination

Image from studioddt.com

Image Classification
Challenges – Deformation

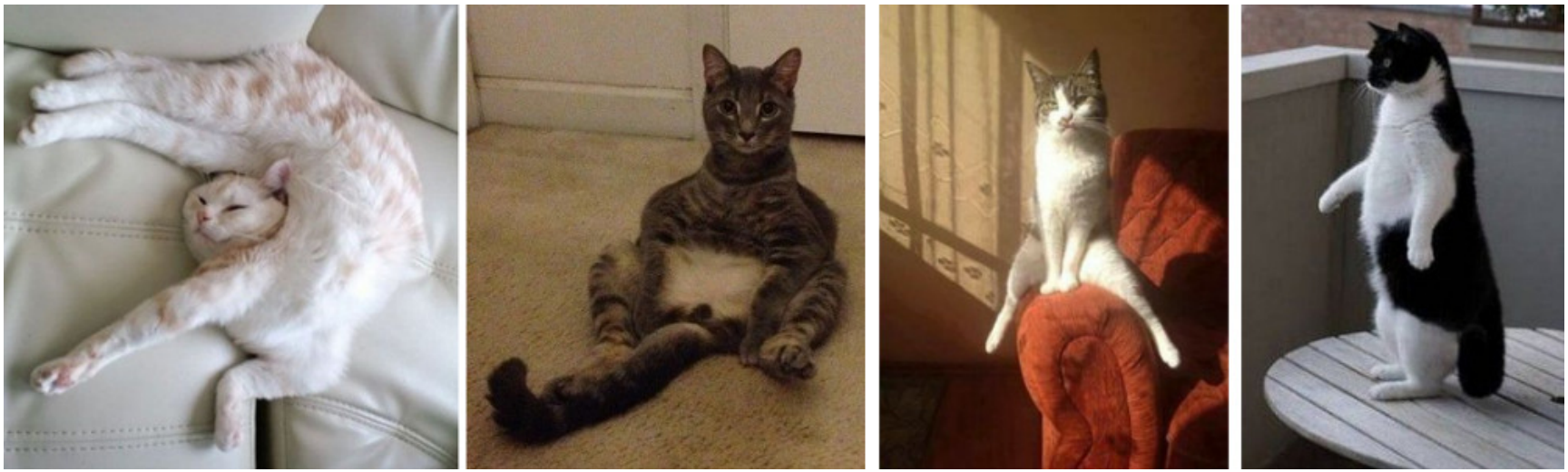


Image from cs231n.github.io

Image Classification
Challenges – Occlusion

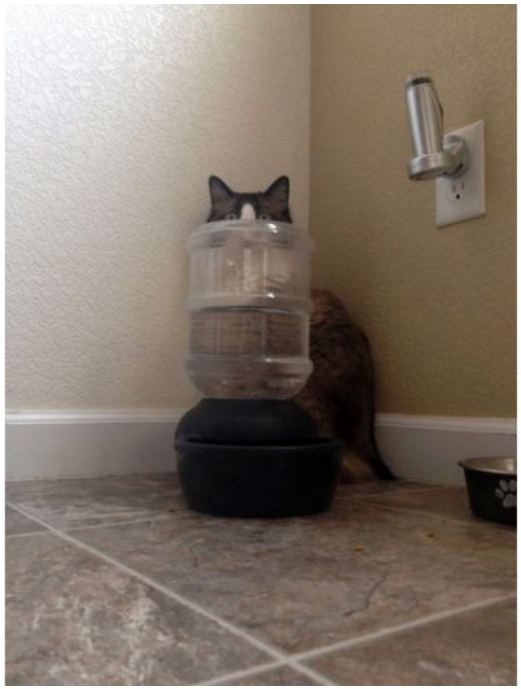




Image from cs231n.github.io

Image Classification
Challenges – Background

Image from cs231n.github.io

Image Classification
Challenges – Intraclass Variation

Image from cs231n.github.io

Image Classification
Datasets

A good classifier must cope with these challenges

- To verify this we need a representative dataset
- Such datasets are usually large

If we employ Machine Learning we also need training data

- Datasets must be disjoint (so need even more data)
- Deep Learning requires lots of data

Image Classification
Datasets

Dataset acquisition takes lots of effort

- Collect many (thousands or more) of images
- Assign class labels to enable automatic training and testing

Data acquisition and processing is central in Deep Learning

- Often the most time-consuming task
- Usually main bottleneck for performance

Thankfully many public datasets are available

Image Classification
Datasets – CIFAR-10

10 classes, 60k images

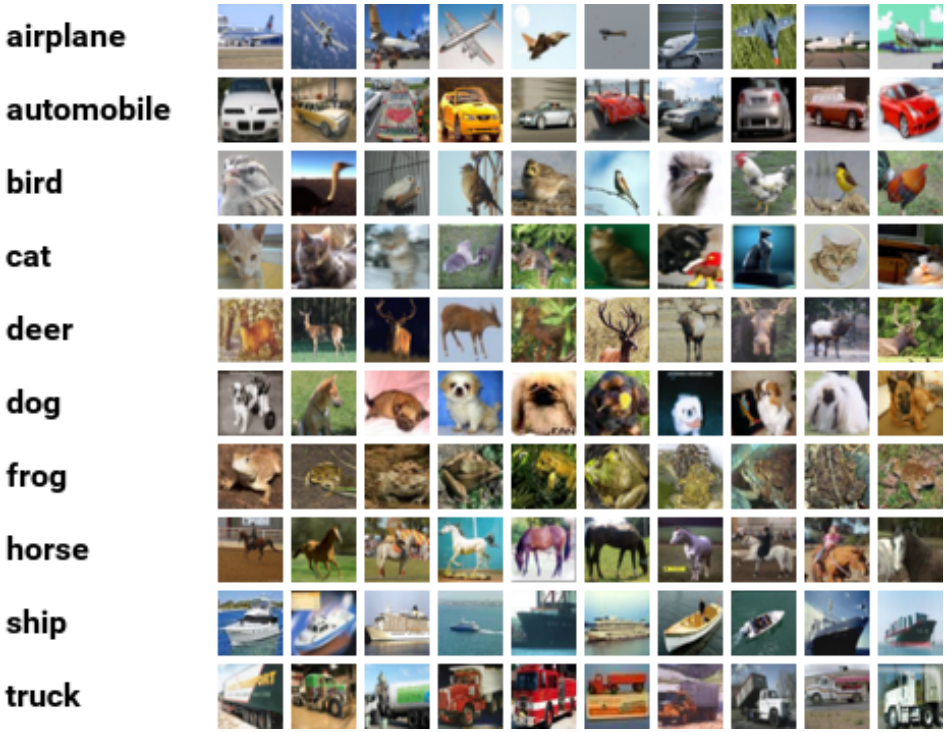
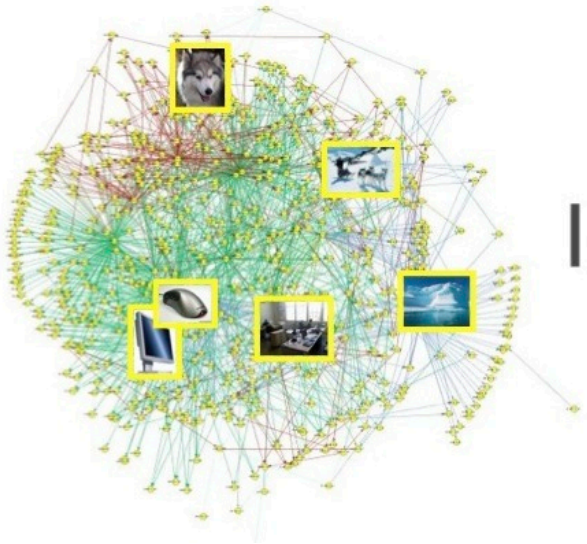


Image from cs.toronto.edu

Image Classification
Datasets – ImageNet

20k classes, 14m images

- Main driver for Deep Learning performance



IMAGENET

Image from umich.edu

Image Classification
Datasets – ImageNet (LSVRC)

LSVRC challenge results started the current Deep Learning hype

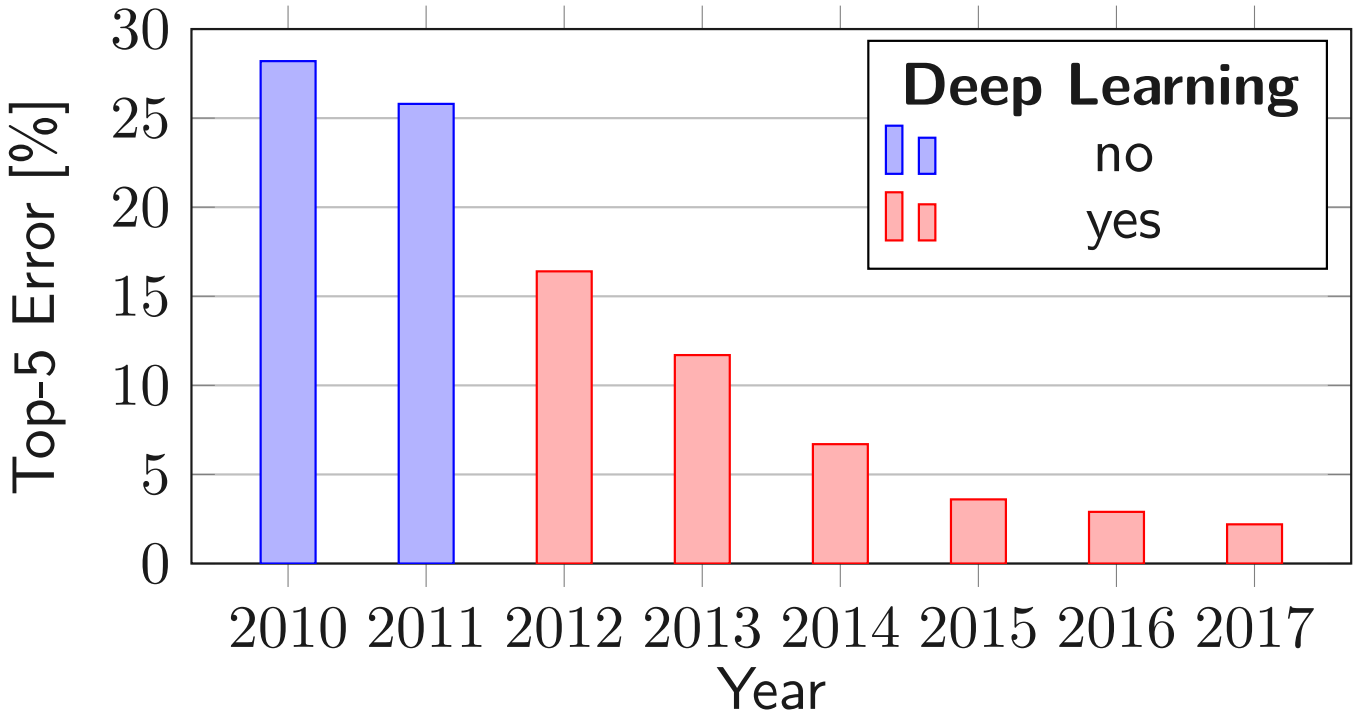


Image Classification
Datasets – COCO

300k images, labels for classification, detection, segmentation, ...

Image from cocodataset.org

Image Classification

Let's build an image classifier

- Should support the classes {dog, cat}
- Using the CIFAR-10 dataset

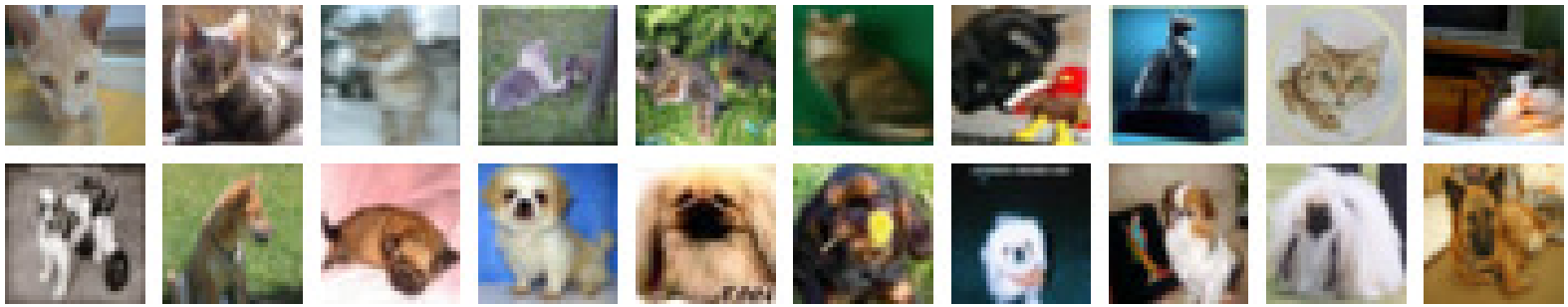


Image from cs.toronto.edu

Image Classification

How can we write an algorithm for this purpose?

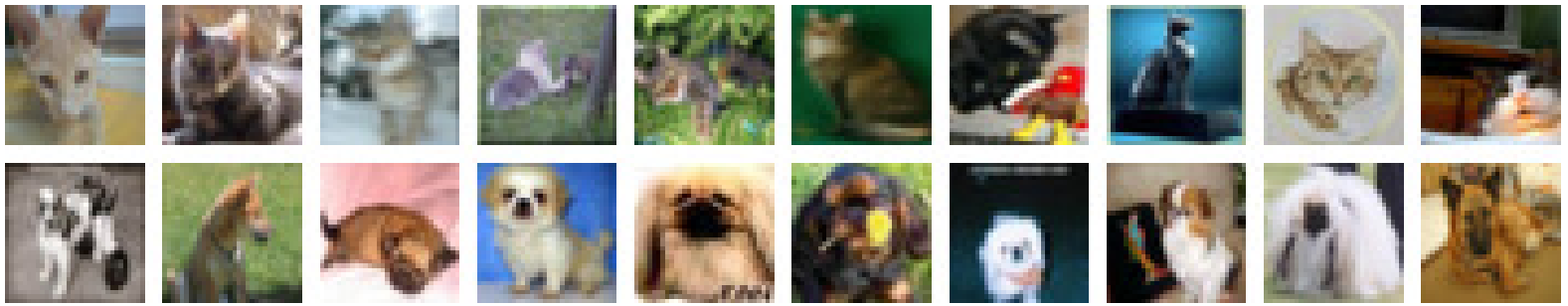


Image from cs.toronto.edu

Image Classification

We cannot!

- No obvious unique and reliable features
- Not clear how to represent and use them

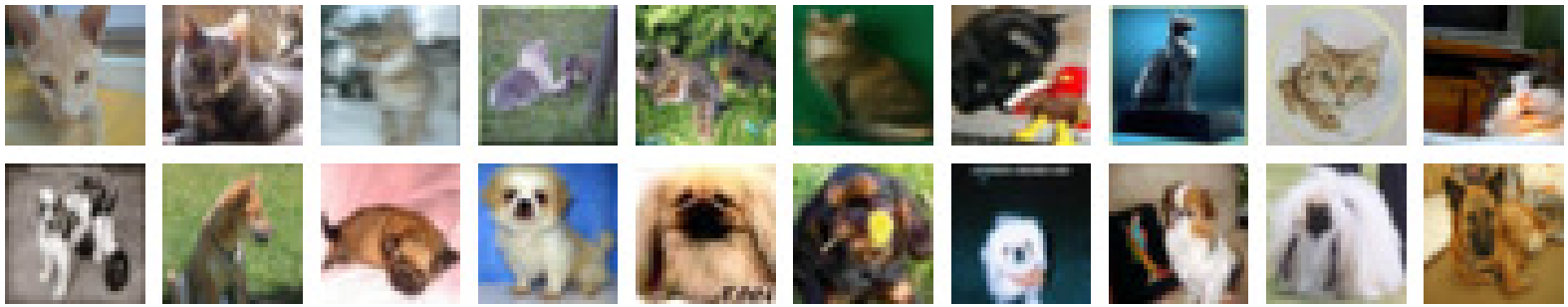


Image from cs.toronto.edu

Image Classification

We humans are incredible image classifiers

But we cannot describe formally how we do so

- Thus the standard `if {} else {}` approach fails

This applies to most vision problems

- Reason we need Machine and Deep Learning