

Deep Learning for Visual Computing

Definitions, Motivation, Image Classification

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Topics

Definitions

- ▶ Deep Learning
- ▶ Convolutional Neural Networks

Motivation: Why care about Deep Learning?

Image classification

- ▶ Definition
- ▶ Challenges
- ▶ Datasets

Definitions

Deep Learning

Learn to solve problems in hierarchical fashion [1]

- ▶ Learn hierarchy of concepts
- ▶ Later concepts build upon earlier (simpler) ones

Graph of concepts has many layers

- ▶ Hence Deep Learning (DL)

Definitions

Convolutional Neural Networks (CNNs)

DL models for data with grid-like structure (e.g. images)

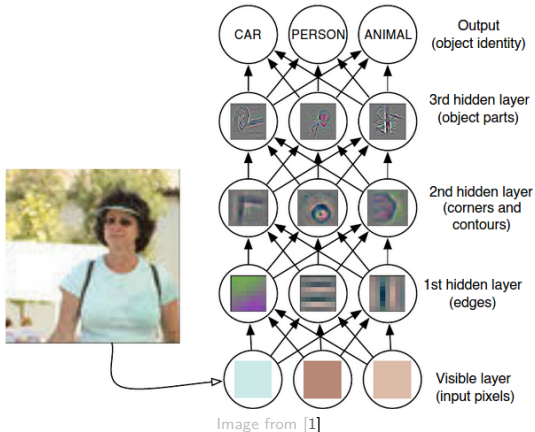
- ▶ Deep feedforward neural networks
- ▶ Include layers that perform convolutions

Most important models for image analysis

- ▶ Focus of this course

Definitions

Convolutional Neural Networks (CNNs)



Motivation

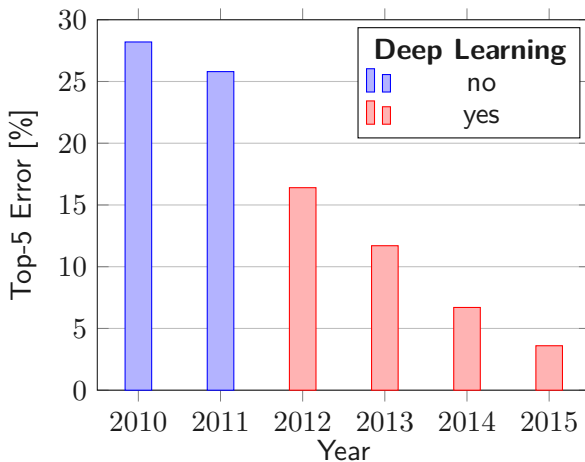
Why care about Deep Learning?

- ▶ Significantly better performance on many tasks
- ▶ Flexible (can do a lot more than classification)
- ▶ Companies want people with experience

Let's see some examples of what Deep Learning can do

Motivation

Image Classification (LSVRC)



Motivation

Image Classification



Image from clarifai.com

Clarifai Demo

GENERAL-V1.3

lake

wood

water

fall

nature

no

reflection

outdoors

landscape

scenic

mountain

wild

Motivation

Object Detection

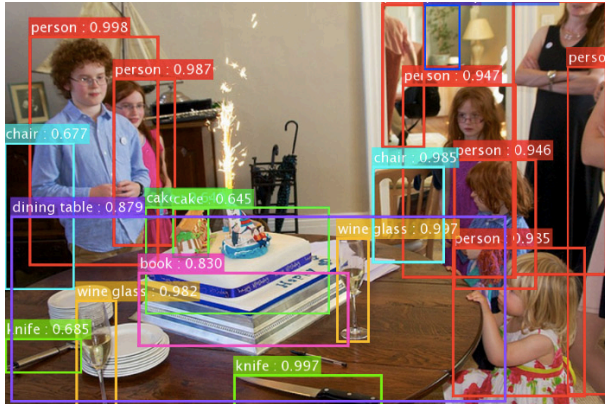


Image from kaiminghe.com

Motivation

Object Detection



Image from [youtube](#)

Motivation

Image Colorization

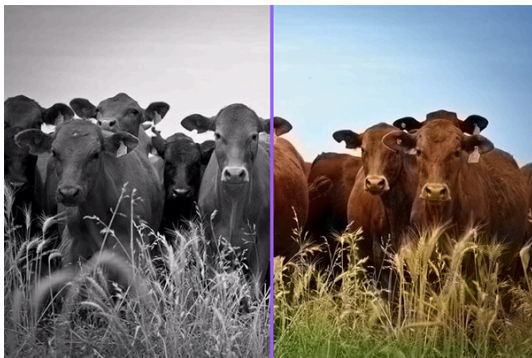


Image from [richzhang.github.io](https://github.com/richzhang)

Motivation

Style Transfer



Image from [2]

Motivation

Facial Landmark Detection



Image from [3]

Motivation

3D Models from Single Images

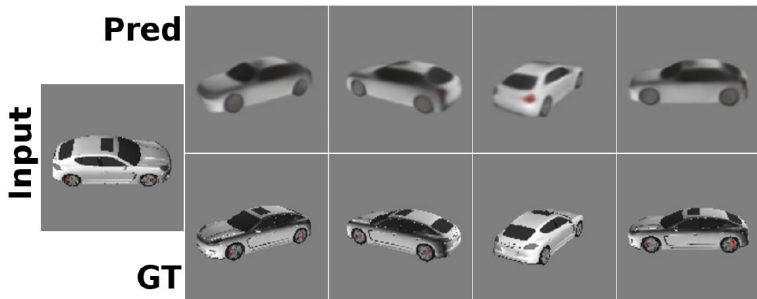
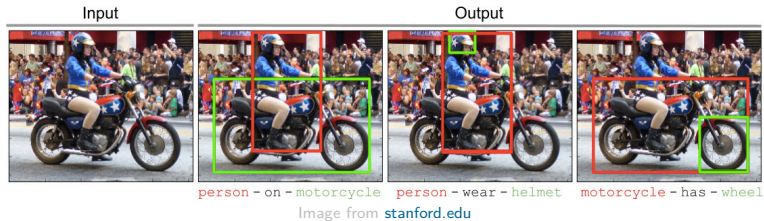


Image from [4]

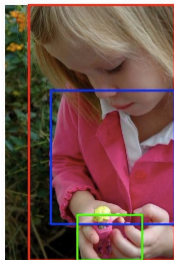
Motivation

Scene Understanding

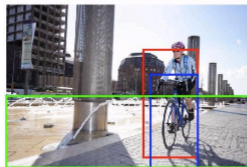


Motivation

Scene Understanding



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.

Image from [5]

Image Classification

One of main image analysis tasks

Task definition

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



⇒ cat

Image from youtube.com

Image Classification

Image belongs to exactly one class in the set

- ▶ Comparatively easy task
- ▶ On some datasets, machines now outperform 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

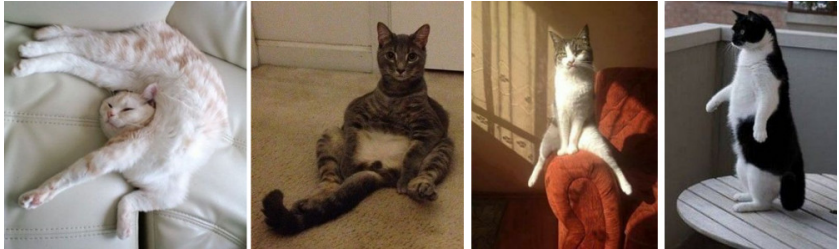


Image from [cs231n.github.io](https://github.com/cs231n)

Image Classification

Challenges – Occlusion

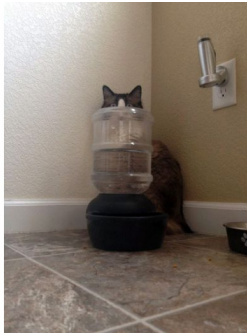


Image from [cs231n.github.io](https://github.com/cs231n)

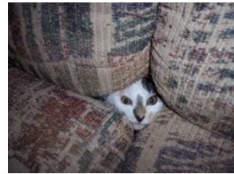


Image Classification

Challenges – Background



Image from cs231n.github.io

Image Classification

Challenges – Intraclass Variation



Image from cs231n.github.io

Computer vision research is dataset-driven

- ▶ Data required for developing and testing
- ▶ Collecting and annotating takes lots of effort

Public image classification datasets available

- ▶ Frees us from having to collect data
- ▶ Facilitates method comparison

Image Classification

Datasets – CIFAR10

10 classes, 60k images

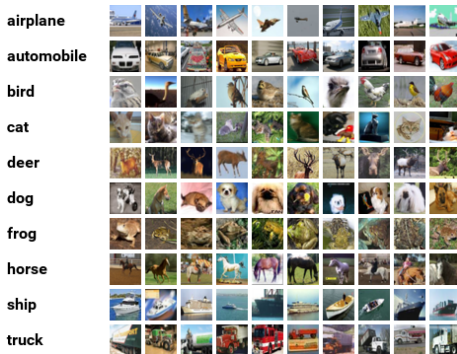


Image from cs.toronto.edu

Image Classification

Datasets – Pascal VOC

20 classes, 29k images

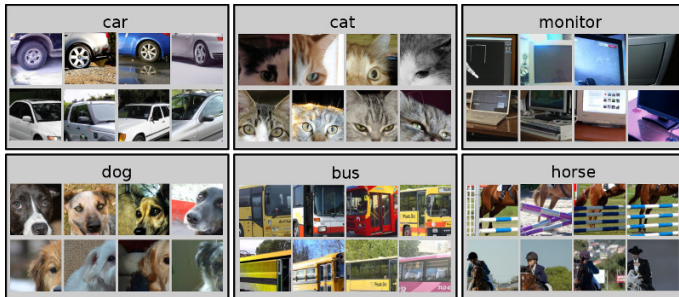


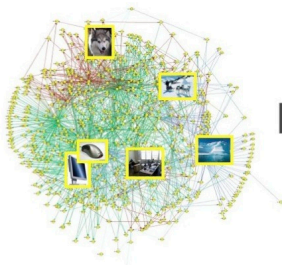
Image from cs.adelaide.edu.au

Image Classification

Datasets – ImageNet (LSVRC)

1000 classes, 1.4m images

- ▶ Subset for annual image classification challenge



IMAGENET

Image from umich.edu

Image Classification

Datasets

We always require three **disjoint** subsets

- ▶ **Training set**: for training (duh)
- ▶ **Validation set**: for tuning hyperparameters
- ▶ **Test set**: for a **final** performance analysis

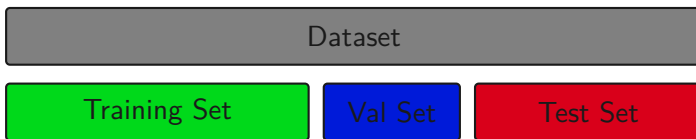


Image Classification

We know the problem and have data

How can we “solve” the image classification problem?

- ▶ Next lecture

Bibliography I

- [1] *Deep learning*, 2016, [Online]. Available:
<http://www.deeplearningbook.org>.
- [2] *Image Style Transfer Using Convolutional Neural Networks*, CVPR, 2016.
- [3] *A Recurrent Encoder-Decoder Network for Sequential Face Alignment*, ECCV, 2016.
- [4] *Multi-View 3D Models from Single Images with a Convolutional Network*, ECCV, 2016.
- [5] *Grounding of Textual Phrases in Images by Reconstruction*, ECCV, 2016.