# Digital Image Processing in Python

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https://github.com/alonyan/DIP

# Workshop goals

The workshop is  an introduction to digital image processing, designed to give you a taste of what's possible with a specific emphasis on microscopy data.

By the end of the workshop, you should:

- Acquire basic understanding and familiarity with computer vision.
- Appreciate the importance of rigorous and systematic image analysis for reproducible and quantitative science.

# Computational Image processing

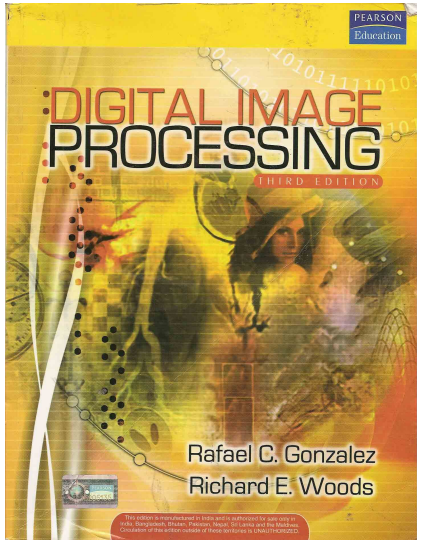
- Image processing is about *extracting* the relevant data from your measurements, but not about analyzing them.

Something something computers …

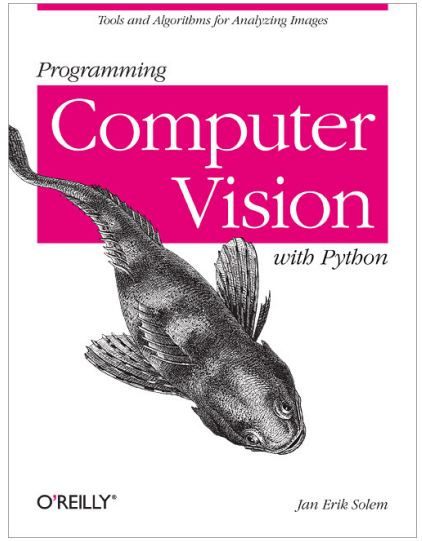
| Monkey ID | M/F | size | Coat Color | Attr 1 | Attr 2 | Attr 3 | … |
|---|---|---|---|---|---|---|---|
| 1 | F | 24 | … | | | | |
| 2 | F | 40 | | | | | |
| 3 | M | 87 | | | | | |
| 4 | M | 21 | | | | | |
| 5 | F | 31 | | | | | |
| 6 | F | 24 | | | | | |
| 7 | F | 54 | | | | | |

# Other resources

MOOC: https://www.mooc-list.com/course/image-analysis-methods-biologists-futurelearn




http://web.ipac.caltech.edu/staff/fmasci/home/astro_refs/Digital_Image_Processing_2ndEd.pdf




http://programmingcomputervision.com/

# Overview of approach

Denoising, thresholding

Image Signal

Low-level vision

Masking, filtering

Conditioned Image Signal

Intermediate-level vision

Feature extraction, feature engineering

Image Derived Parameters

High-level vision

Understanding Image Content

All parameters and features are user defined, many heuristic (Wheelness of an object…)

# 2012 – AlexNet : Breakthrough in computer vision

## ImageNet Classification with Deep Convolutional Neural Networks

**Alex Krizhevsky**
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**Ilya Sutskever**
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**Geoffrey E. Hinton**
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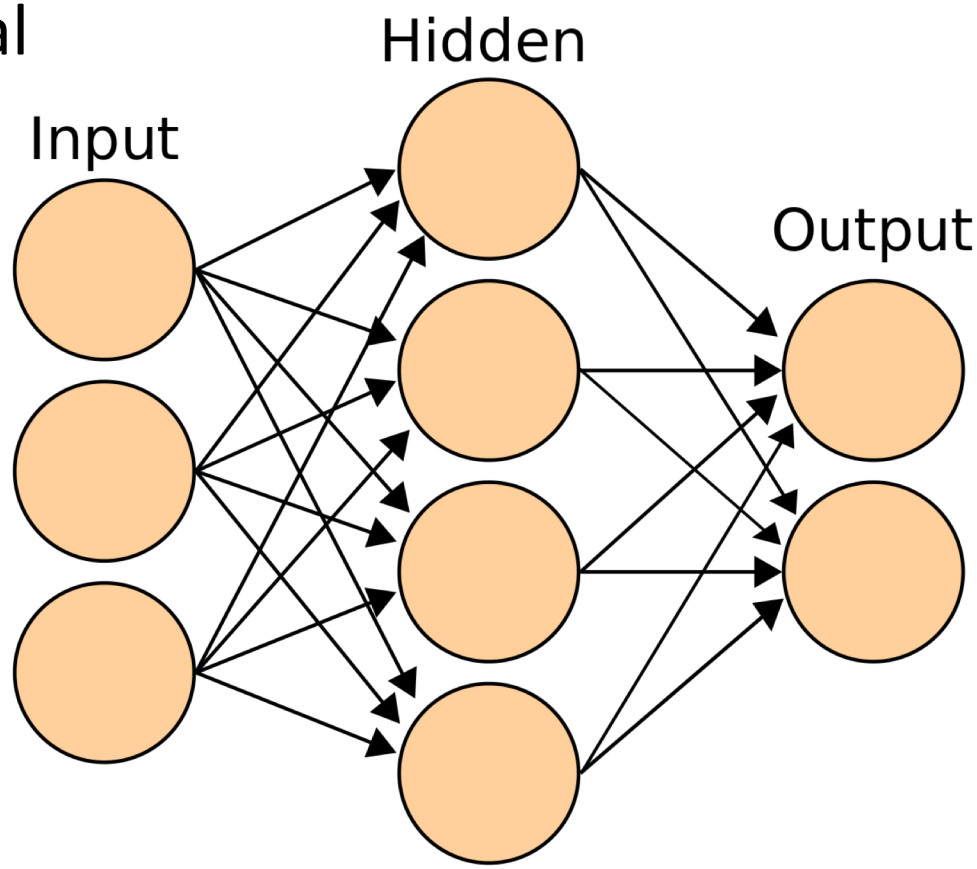
Won ImageNet – a image recognition competition by a wide margin

Onset of ***Deep learning***

# Artificial Neural Networks (ANNs)

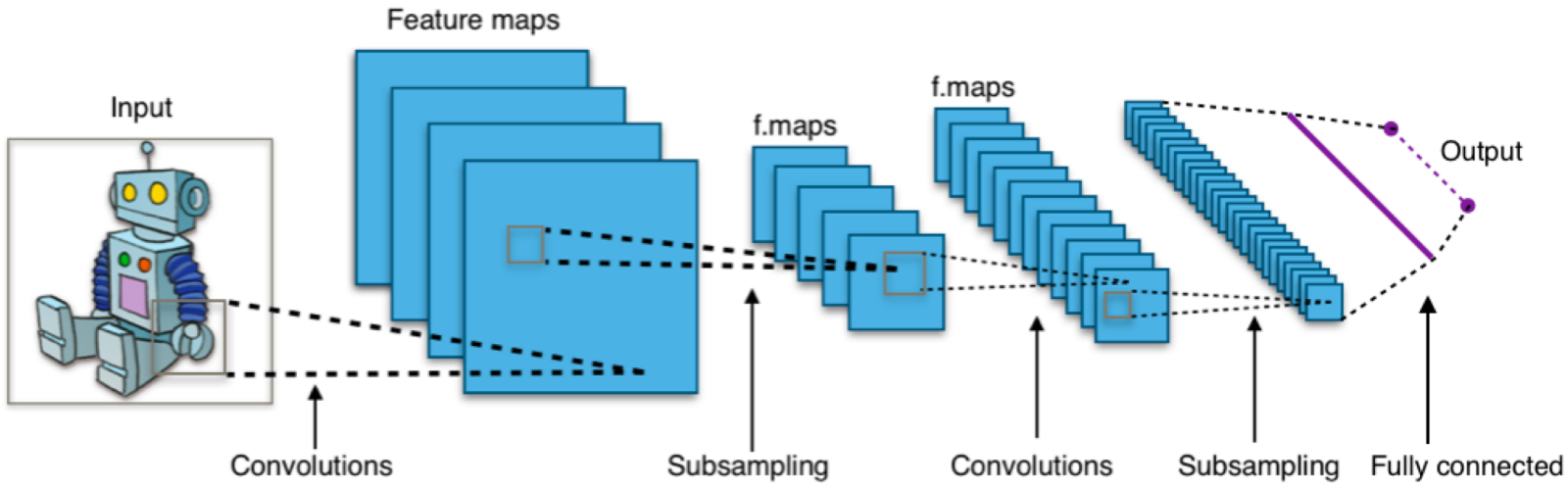
- Inspired by biology, ANNs are computational systems that can ***learn*** a set of parameters that translate a given input to a desired output.
- ANNs are ***trained*** by providing large sets of annotated data (training set).
- Ideally, after training, ANNs are capable of using the learned information to interpret new data.




The theory of these has been developed since the 40s
Was always considered cute but computationally unfeasible

# Convolutional Neural Networks (CNNs)

- CNNs are ANNs that use convolution (e.g. filtering) as part of the network architecture.
- They are particularly useful for computer vision as they are able to learn features over a wide range of scales

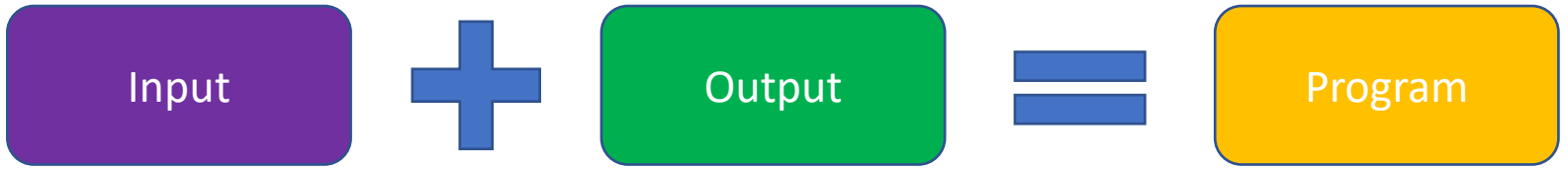


# Conceptual differences

Traditional programming:


Logic is predefined by the programmer

Machine learning:




Logic is learned from examples

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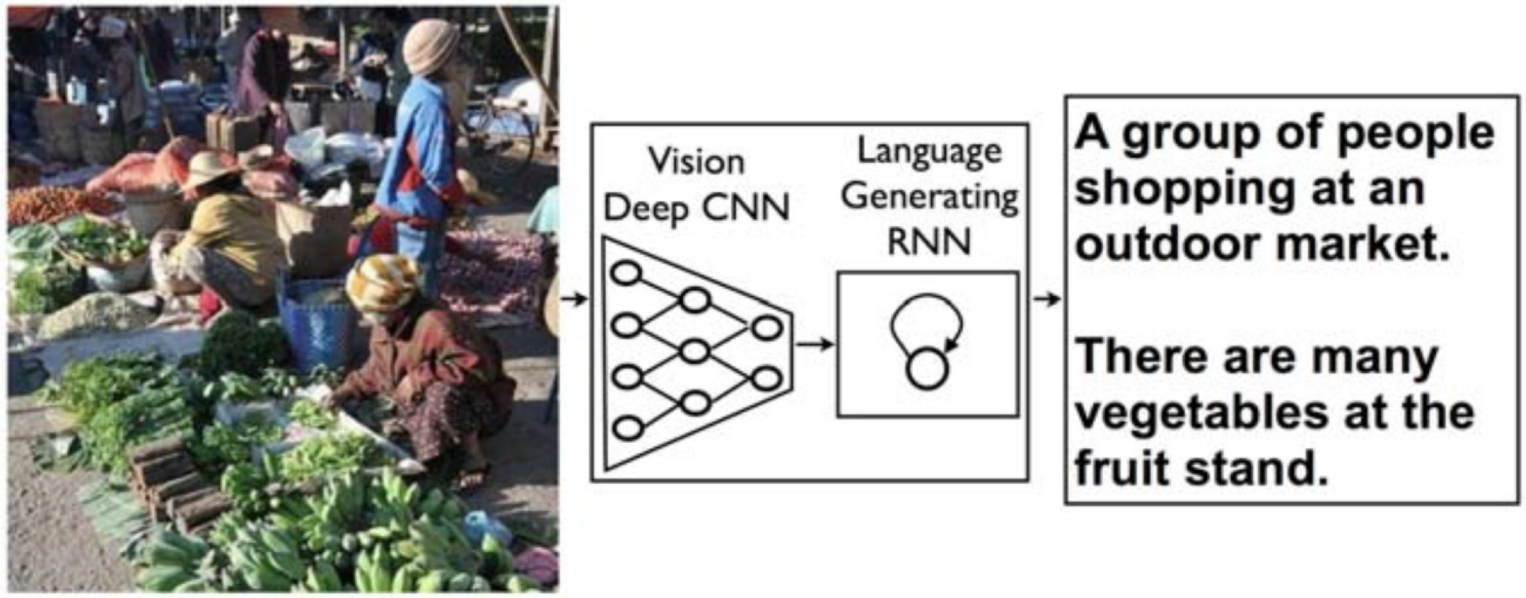
The big breakthrough was computing everything on GPUs, which are way more efficient for these tasks.

>47000 citations as of Oct. 2019

*not technically first, but most influential

# 2014 – From image classification to image description

- Image classification was then extended to the more challenging task of generating descriptions (captions) for images.




Google, Stanford University

# 2014 – From image classification to image description

- Image classification was then extended to the more challenging task of generating descriptions (captions) for images.


"man in black shirt is playing guitar."


"construction worker in orange safety vest is working on road."


"two young girls are playing with legos toy."


"boy is doing backflip on wakeboard."

Google, Stanford University

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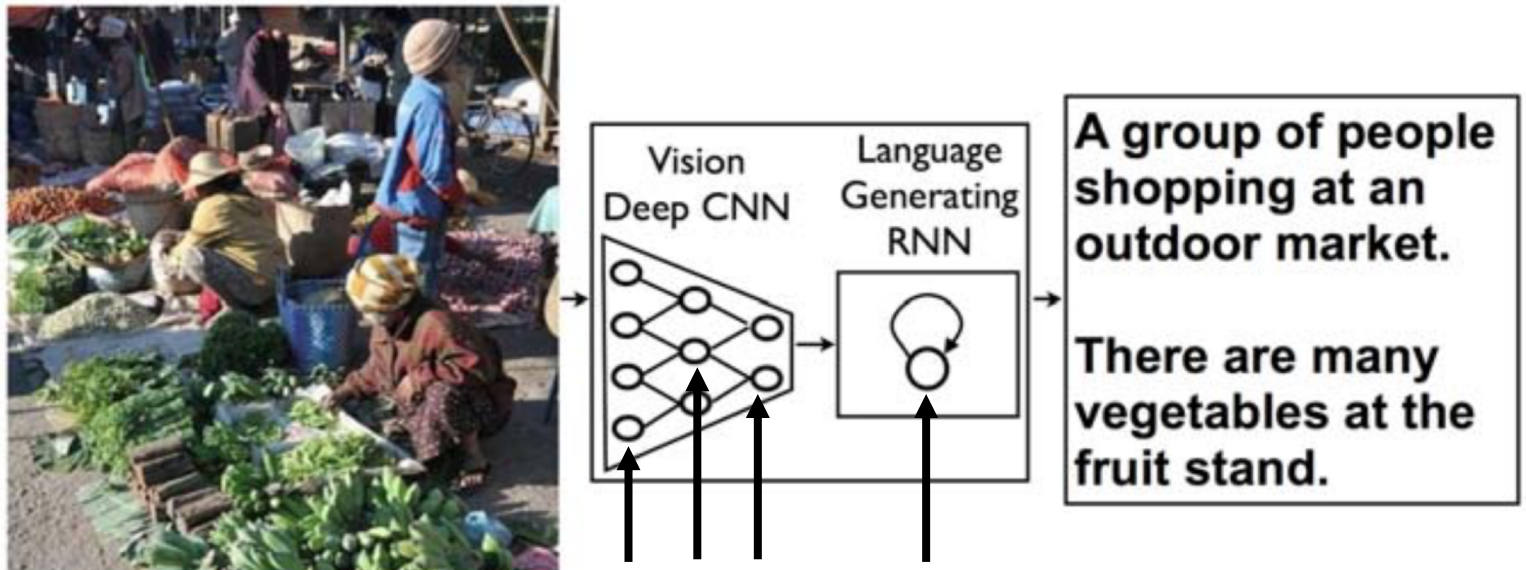
- Image classification was then extended to the more challenging task of generating descriptions (captions) for images.




All of these parameters are ***learned*** by the computer during ***training***

Google, Stanford University

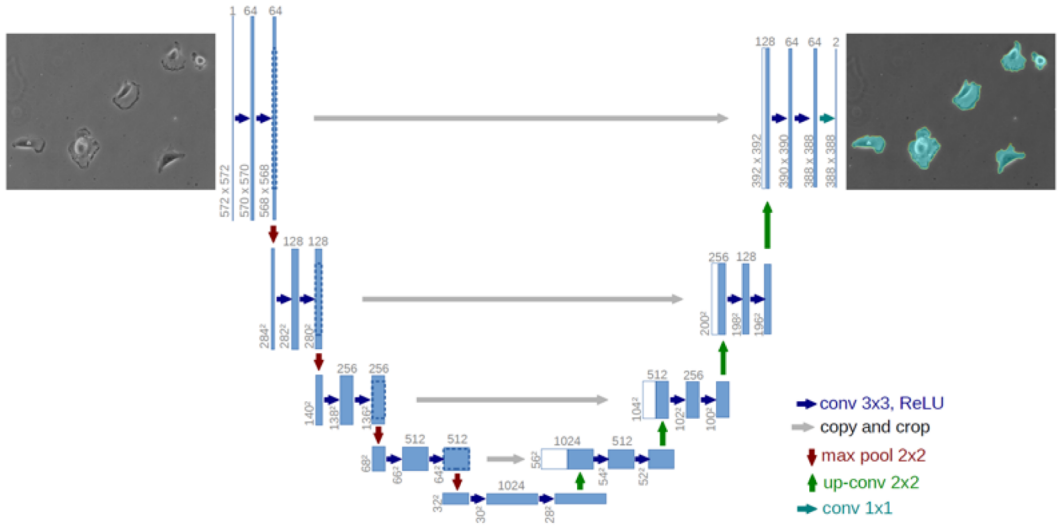
# 2015 – U-Net, First biological application of CNNs

## U-Net: Convolutional Networks for Biomedical Image Segmentation

Olaf Ronneberger, Philipp Fischer, Thomas Brox

*(Submitted on 18 May 2015)*

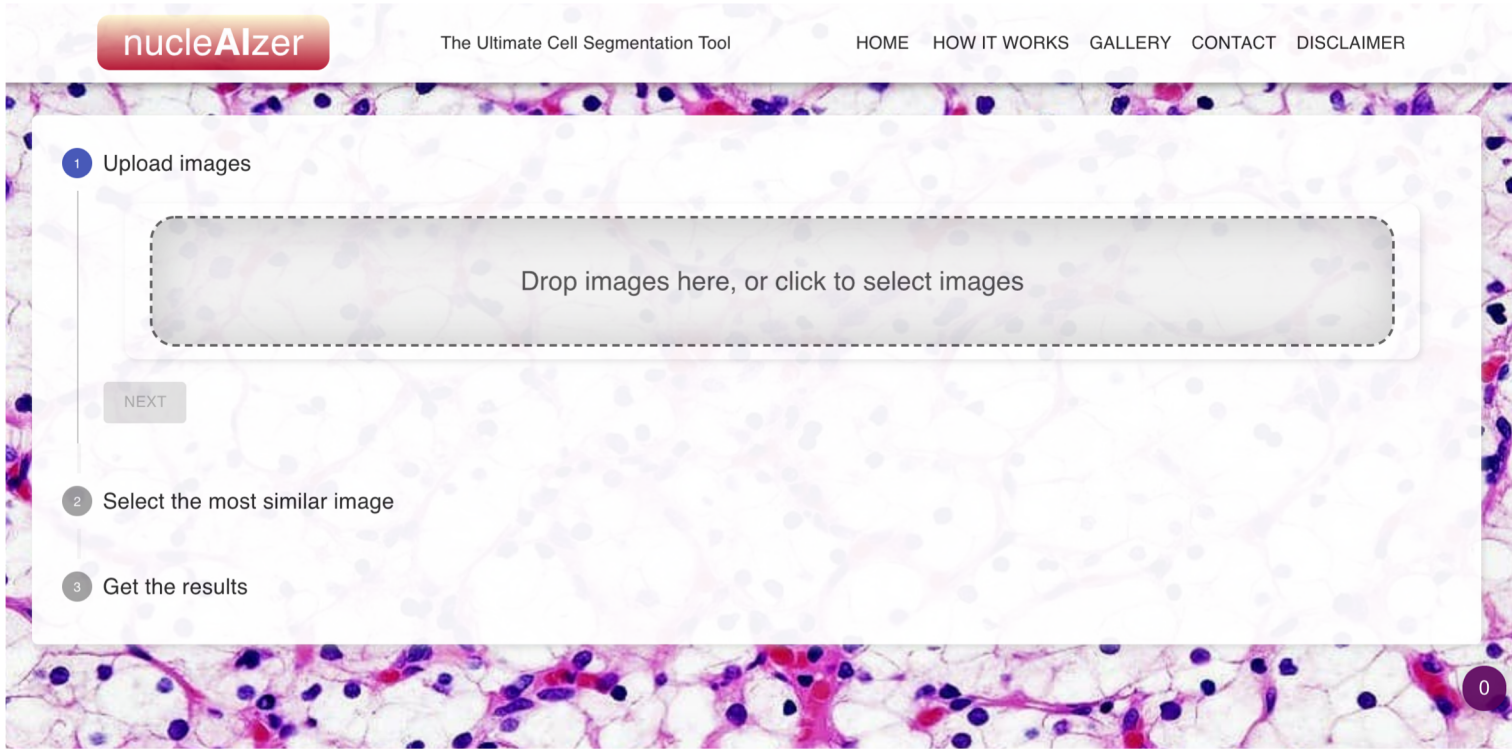
There is large consent that successful training of deep networks requires many thousand annotated training samples. In this paper, we present a network and training strategy that relies on the strong use of data augmentation to use the available annotated samples more efficiently. The architecture consists of a contracting path to capture context and a symmetric expanding path that enables precise localization. We show that such a network can be trained end-to-end from very few images and outperforms the prior best method (a sliding-window convolutional network) on the ISBI challenge for segmentation of neuronal structures in electron microscopic stacks. Using the same network trained on transmitted light microscopy images (phase contrast and DIC) we won the ISBI cell tracking challenge 2015 in these categories by a large margin. Moreover, the network is fast. Segmentation of a 512x512 image takes less than a second on a recent GPU. The full implementation (based on Caffe) and the trained networks are available at this http URL .



# 2018 – Deep learning based web tools

- http://deepcell.org/
- http://nucleaizer.org/

Future is bright!



# Open questions

- **Interpretability** of hidden layers
- **Learning from few examples**: On a large no. of problems, humans learn from very few examples, like hand-writing recognition. Machines require many more examples.

# For more on this

- https://qcb.ucla.edu/collaboratory-2/workshops/w17-machine-learning-with-python/
- https://www.coursera.org/learn/machine-learning
- https://www.fast.ai/
- https://www.udemy.com/course/advanced-computer-vision/
- https://www.udemy.com/course/python-for-computer-vision-with-opencv-and-deep-learning/
- https://www.udacity.com/course/deep-learning-nanodegree--nd101

# Please help us get better! (by filling a short survey)