Machine Learning Approaches for advanced Industrial Applications

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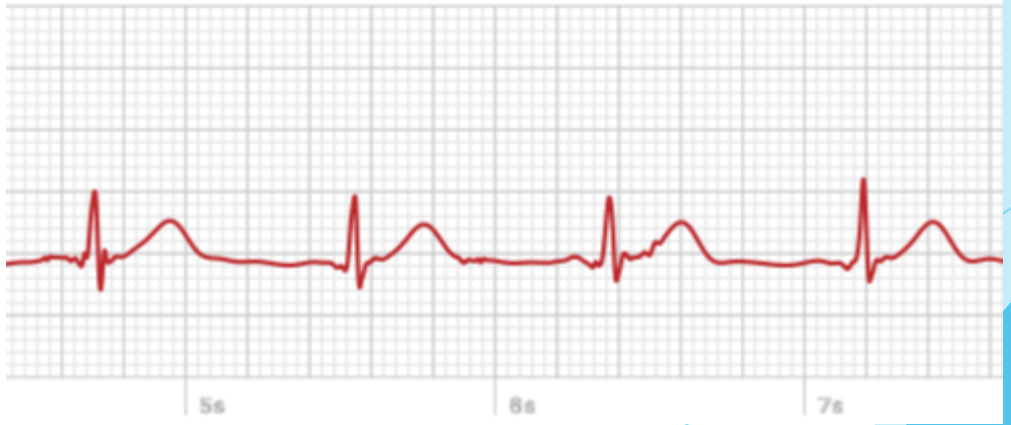
Session 3 – Image Classification using Deep Learning

Signal Processing

Signal

- Function that "conveys information about the behaviour or attributes of some phenomenon“
- Y = f(x)
- X is independent, Y is dependent
- Ex: ECG signal:
  - time is independent variable
  - lead potential is dependent variable



Can you name a few signals?

Signal Processing

- **Science** that concerns the analysis, synthesis, and modification of signals
- Analysis:
  - ECG analysis: HR detection, anomalies
  - IMU analysis: fall detection
- Synthesis:
  - Voice signals are synthesized for communication via mobile phones
  - Musical tone synthesis
- Modification
  - Amplifiers
  - Modulation AM/FM
  - Filtering

Image Processing

- What is an Image and How Image is formed?

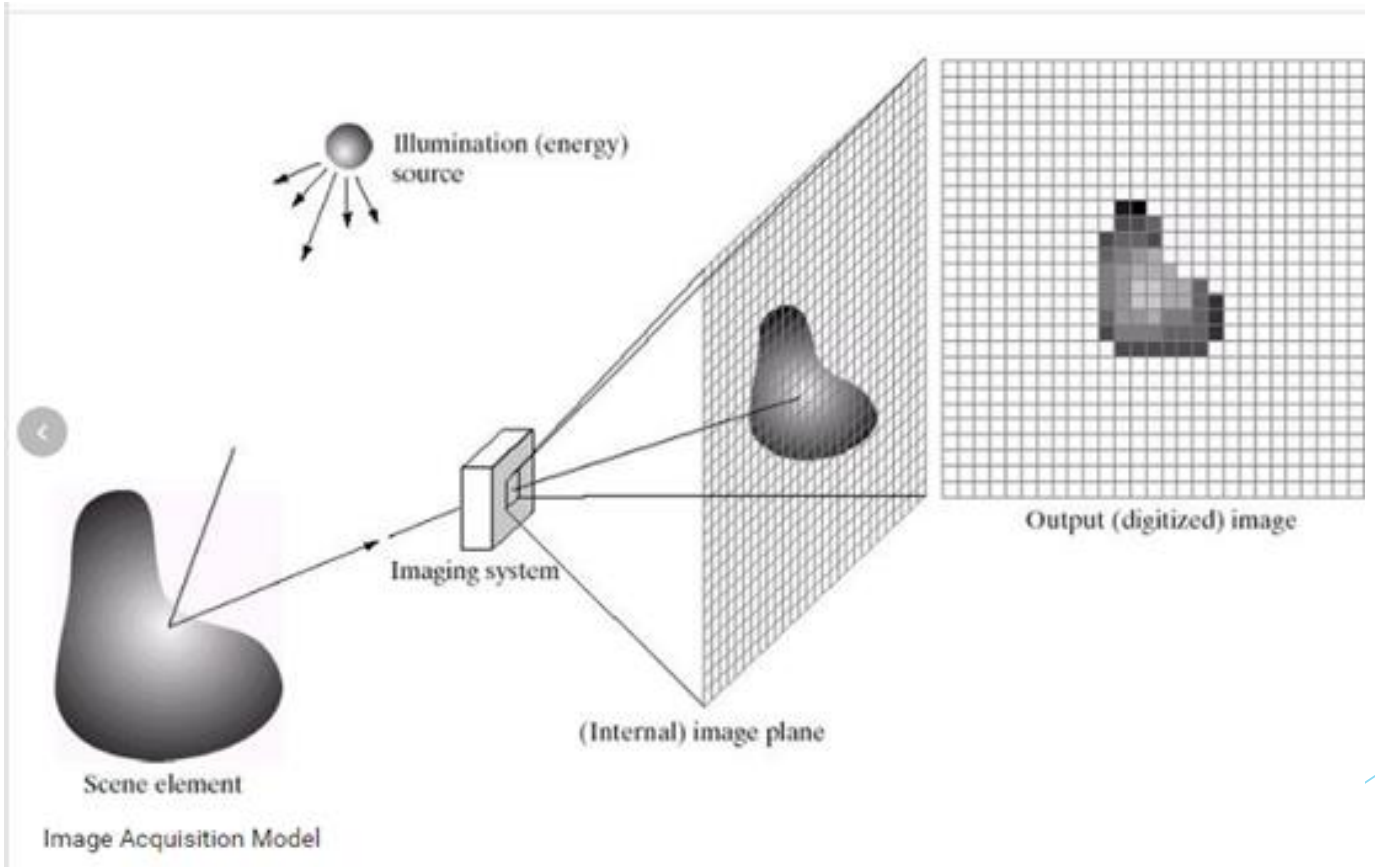
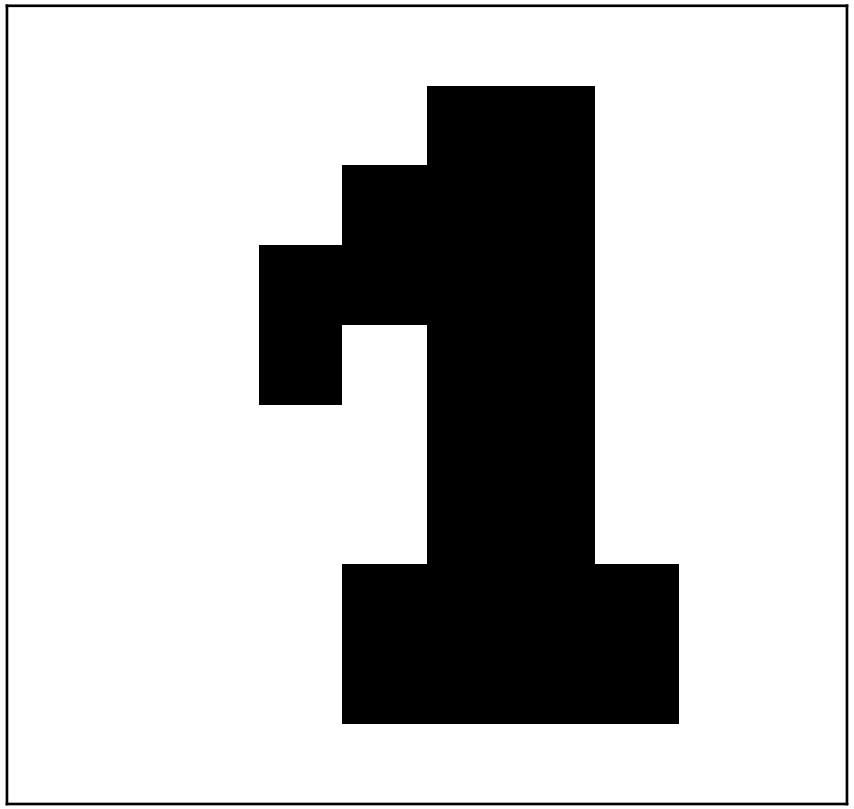


Image Acquisition Model

Image Structure



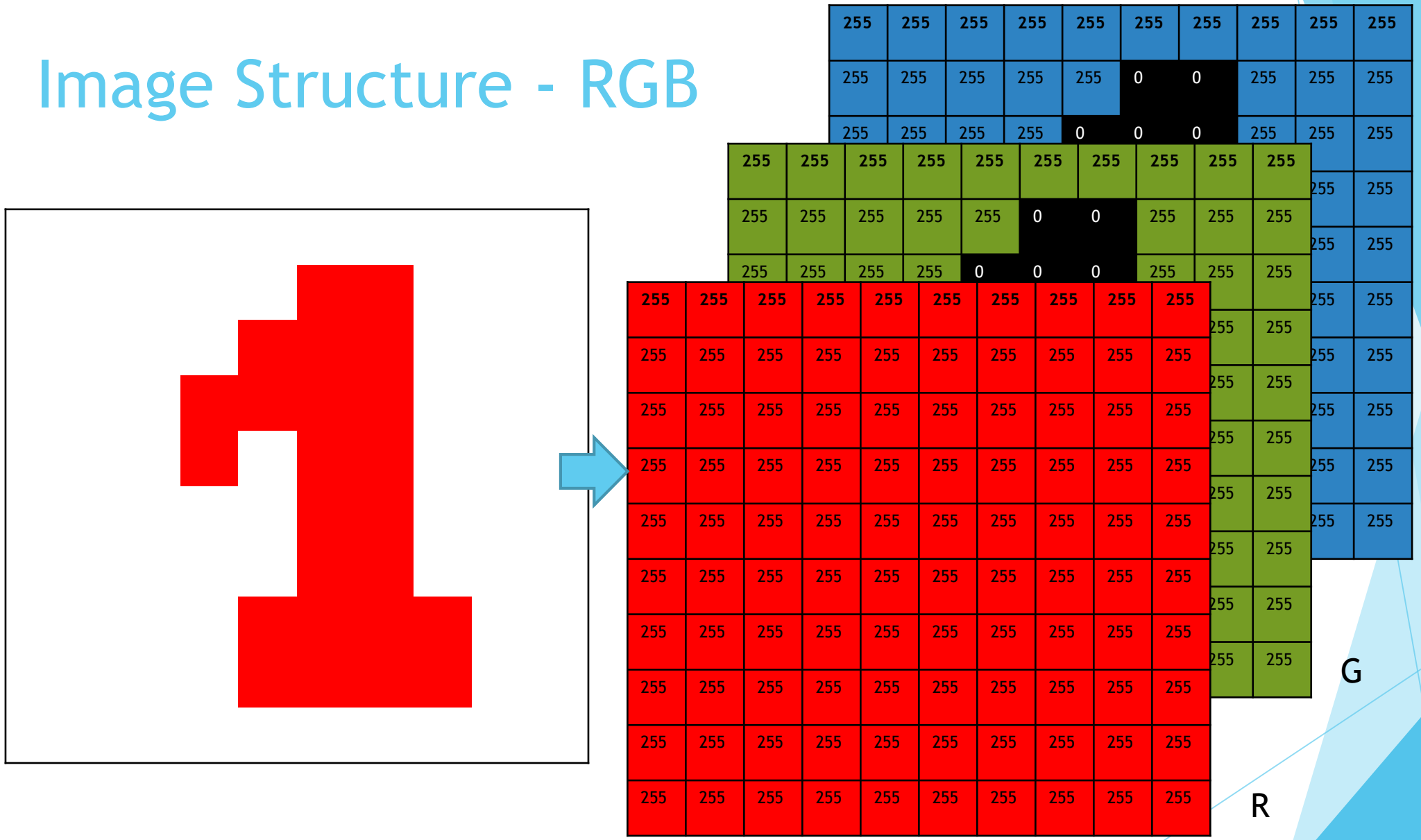
255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	0	0	255	255	255
255	255	255	255	0	0	0	255	255	255
255	255	255	0	0	0	0	255	255	255
255	255	255	0	255	0	0	255	255	255
255	255	255	255	255	0	0	255	255	255
255	255	255	255	255	0	0	255	255	255
255	255	255	255	0	0	0	0	255	255
255	255	255	255	0	0	0	0	255	255
255	255	255	255	255	255	255	255	255	255

10x10 matric uint8

Contd..

- Image is a 2 dimensional signal
- Independent variables are space! (f(x,y))
- Image Processing is the Analysis, Synthesis and Modification of Images
- Analysis
  - Medical Imaging Scans CT, MRI
  - Satellite image analysis
  - Difference detection
- Synthesis
  - Heat map generation
  - Game development and Entertainment
- Modification - Basic operations on Images
  - Image enhancement – removing noise and sharpening an image
  - Image segmentation – isolating objects of interest and gathering statistics
  - Image registration – aligning multiple images from different camera sources

Image Structure - RGB



Deep Learning for Images

- 1D example

	ip1	op
Training	6000	15000
	4000	23241
	4500	43000
	4230	9990
	2227	69900
Validation	1150	3499
	5000	12447
Deployment	2815	?
	4300	?

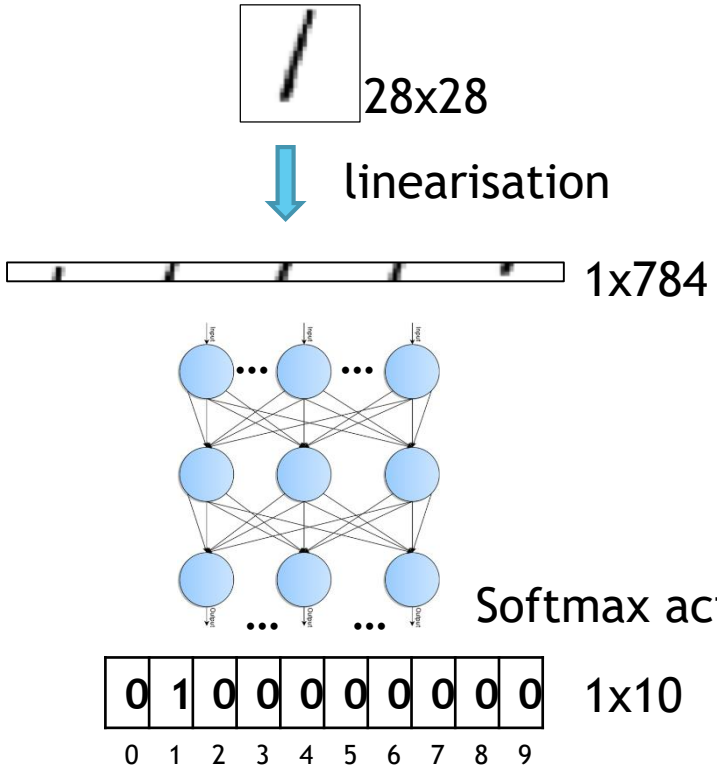
DL not required

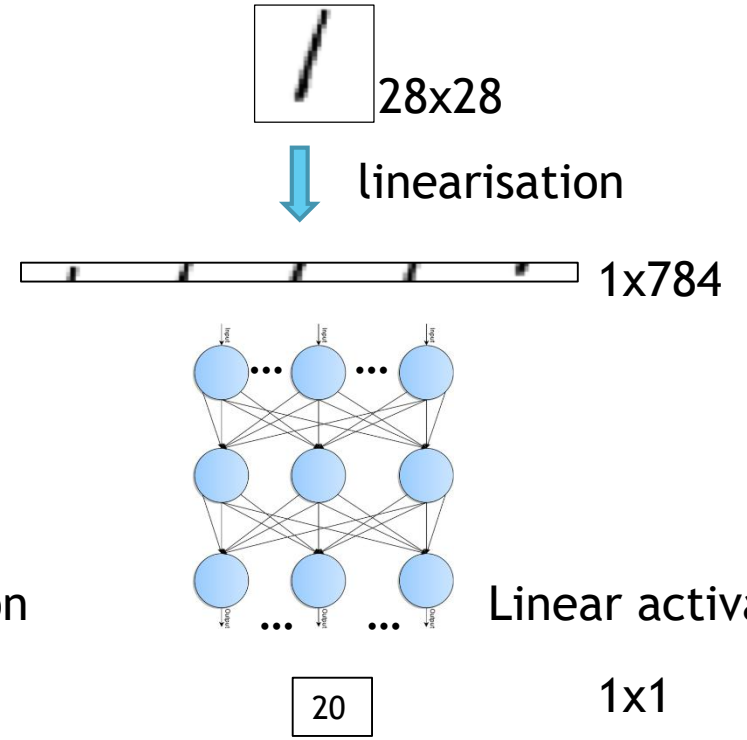
- 2D example

	ip1	op
Training		1
		2
		3
	...	...
		9
Validation		4
		5
Deployment		?
		?

DL required

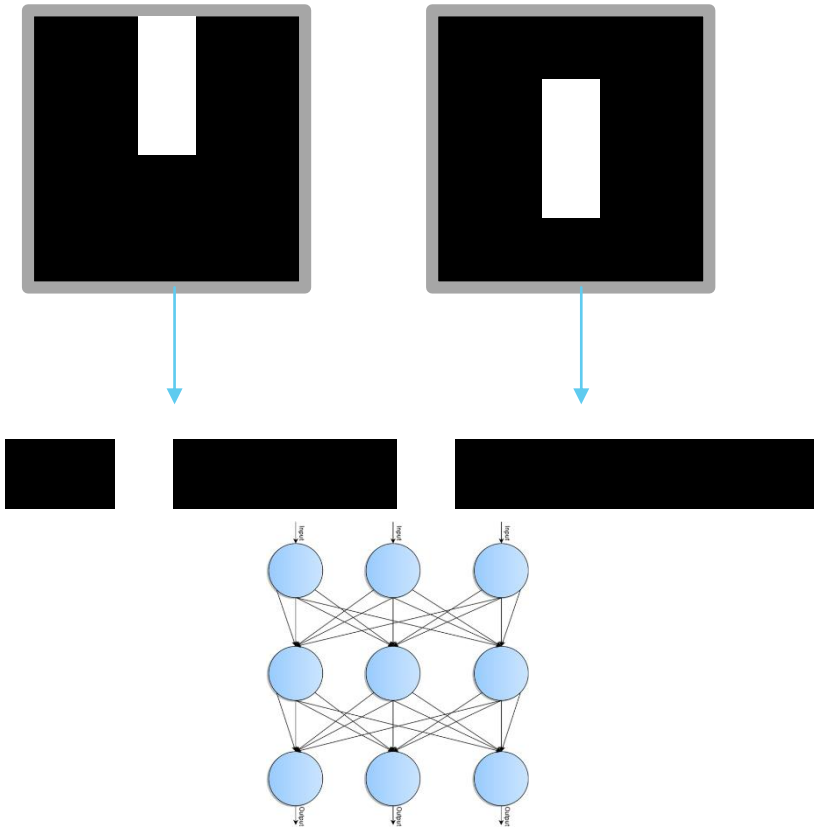
Simple ANN on Linearised Images





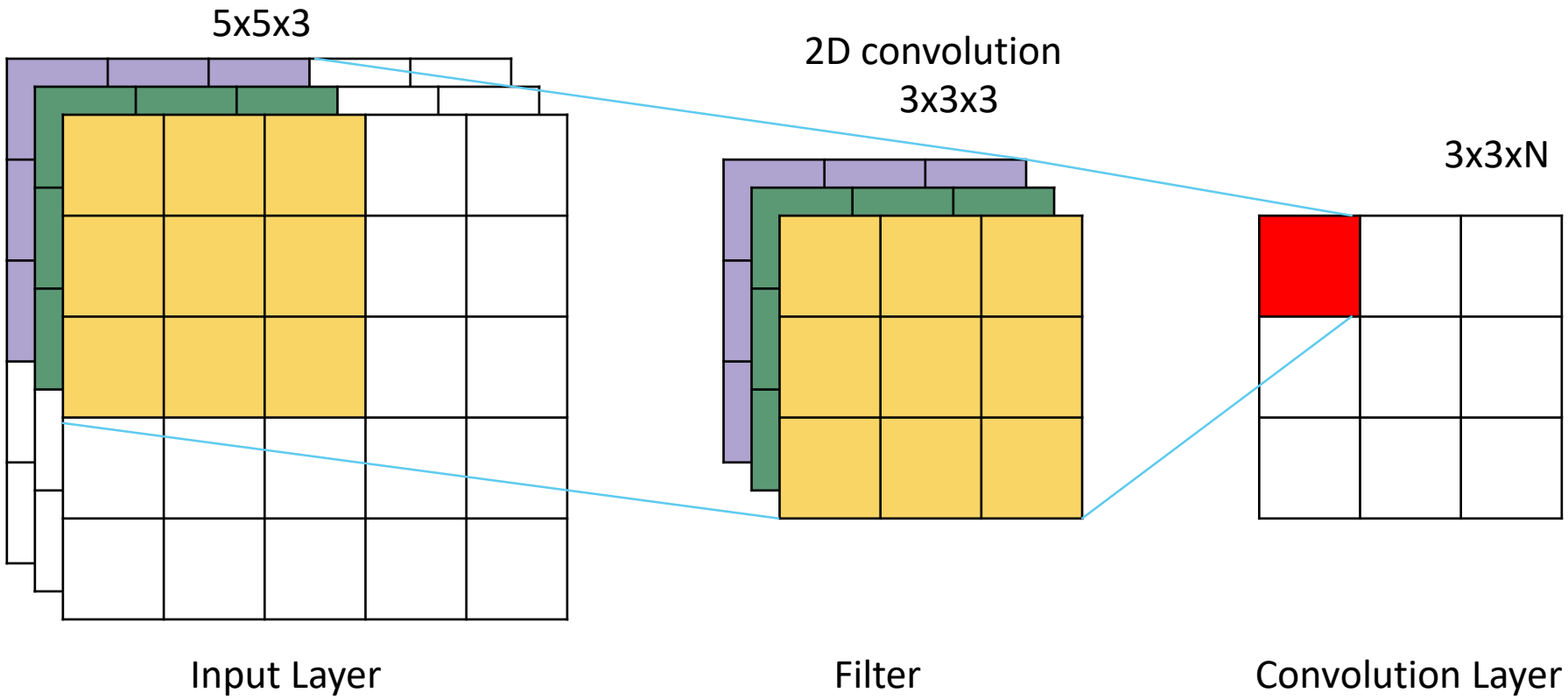
Advancements in ANN

- Problem with linearization



Solution:
Deep Neural Networks
- Convolution Neural Networks
  - AlexNet
  - VGG
  - GoogLeNet

Convolution Neural Networks

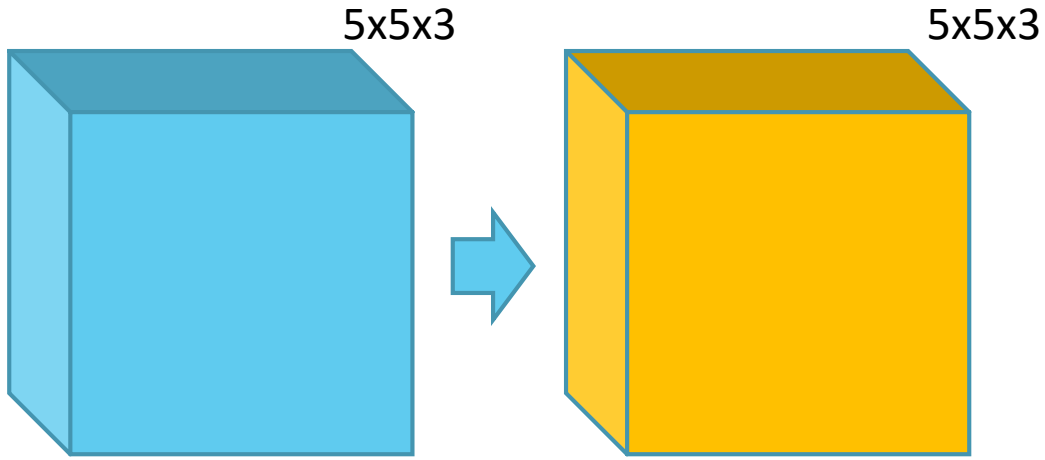


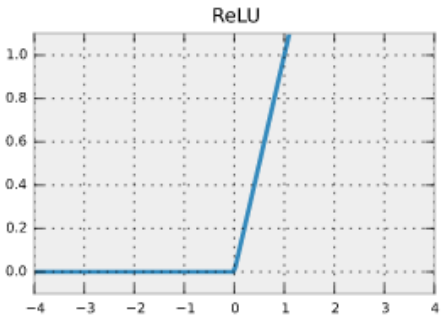
Important parameters

- Kernel size
- Stride

Activation Function

- Rectified Linear unit (ReLu)

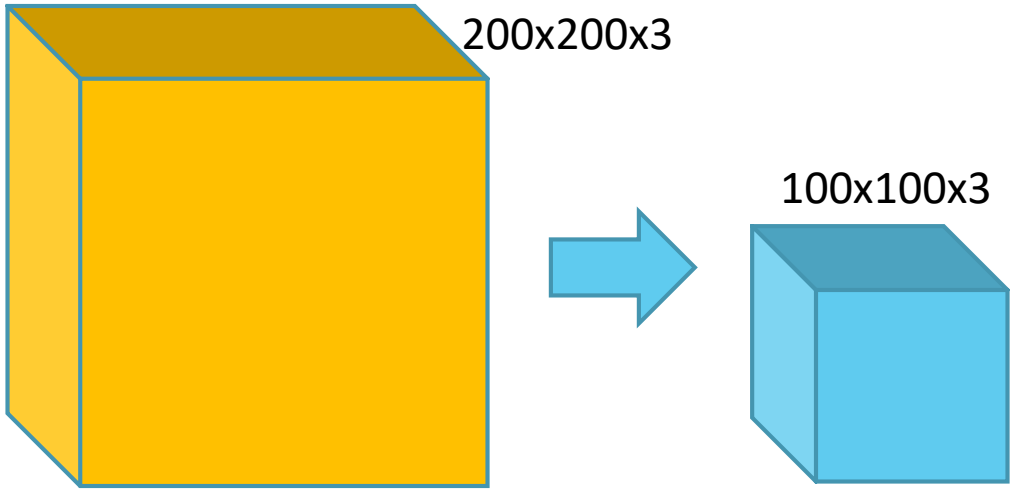




https://www.youtube.com/watch?v=SQ67NBCLV98

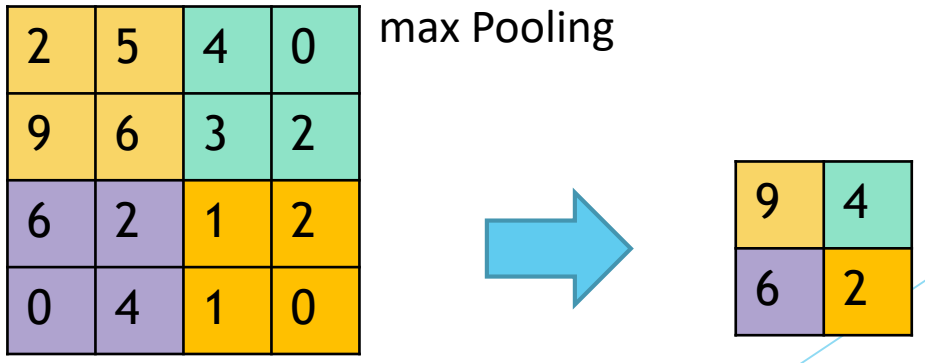
Pooling

- Downsampling

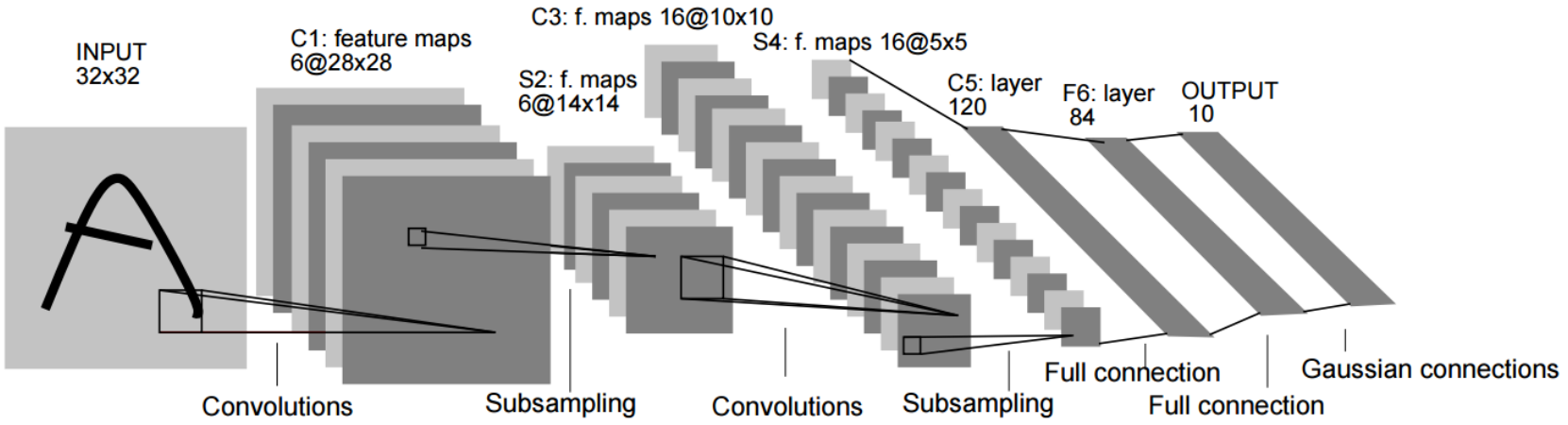


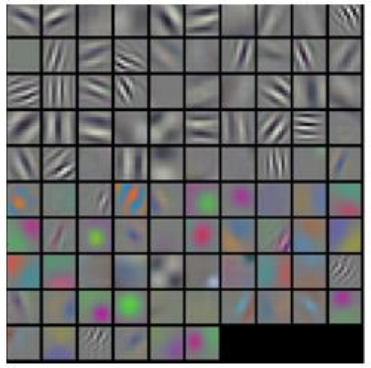
Use:

- To move away from spatial representation to latent representations
- To reduce parameters



Case Study – LeNet-5





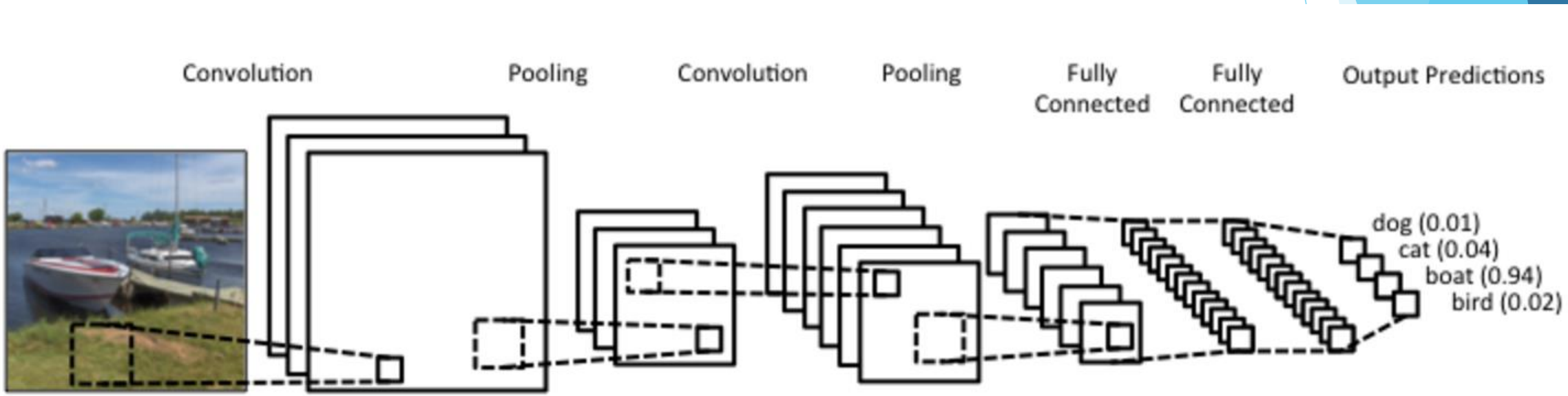
Visualizations of filters

Y. LeCun, L. Bottou, Y. Bengio and P. Haffner: **Gradient-Based Learning Applied to Document Recognition**, *Proceedings of the IEEE, 86(11):2278-2324, November **1998**, \cite{lecun-98}.*

ConvNet Visualization

- Convnet visualization helps to gain insights into what it does
- Inspect a CNN's robustness

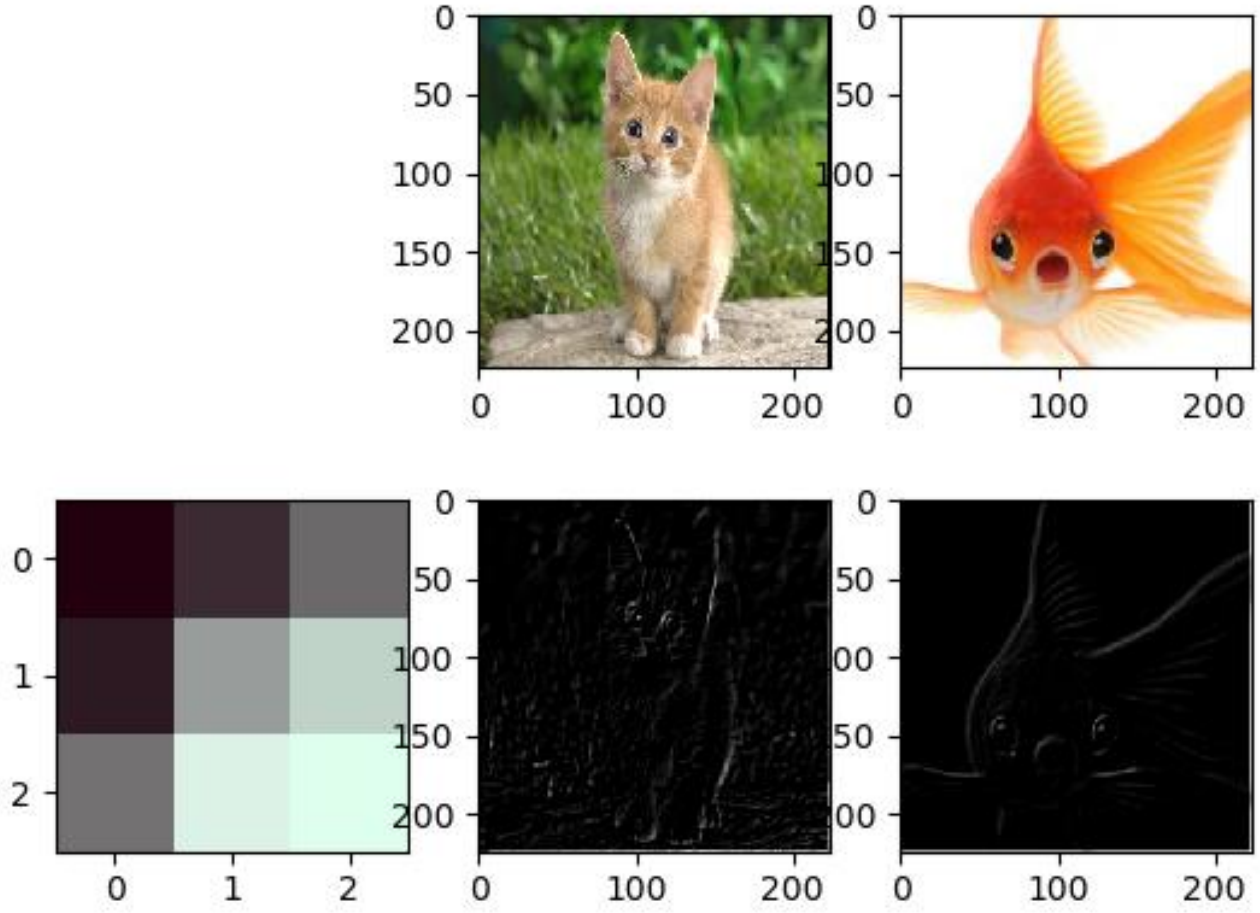
- Two ways
  - Given an image, observe the Activations for each layer
  - Given an activation, observe for different images
  - Perform by obstructing part of the image


Convolution
Pooling
Convolution
Pooling
Fully Connected
Fully Connected
Output Predictions
dog (0.01)
cat (0.04)
boat (0.94)
bird (0.02)

Given an image, observe the Activations for each layer

- Layer1

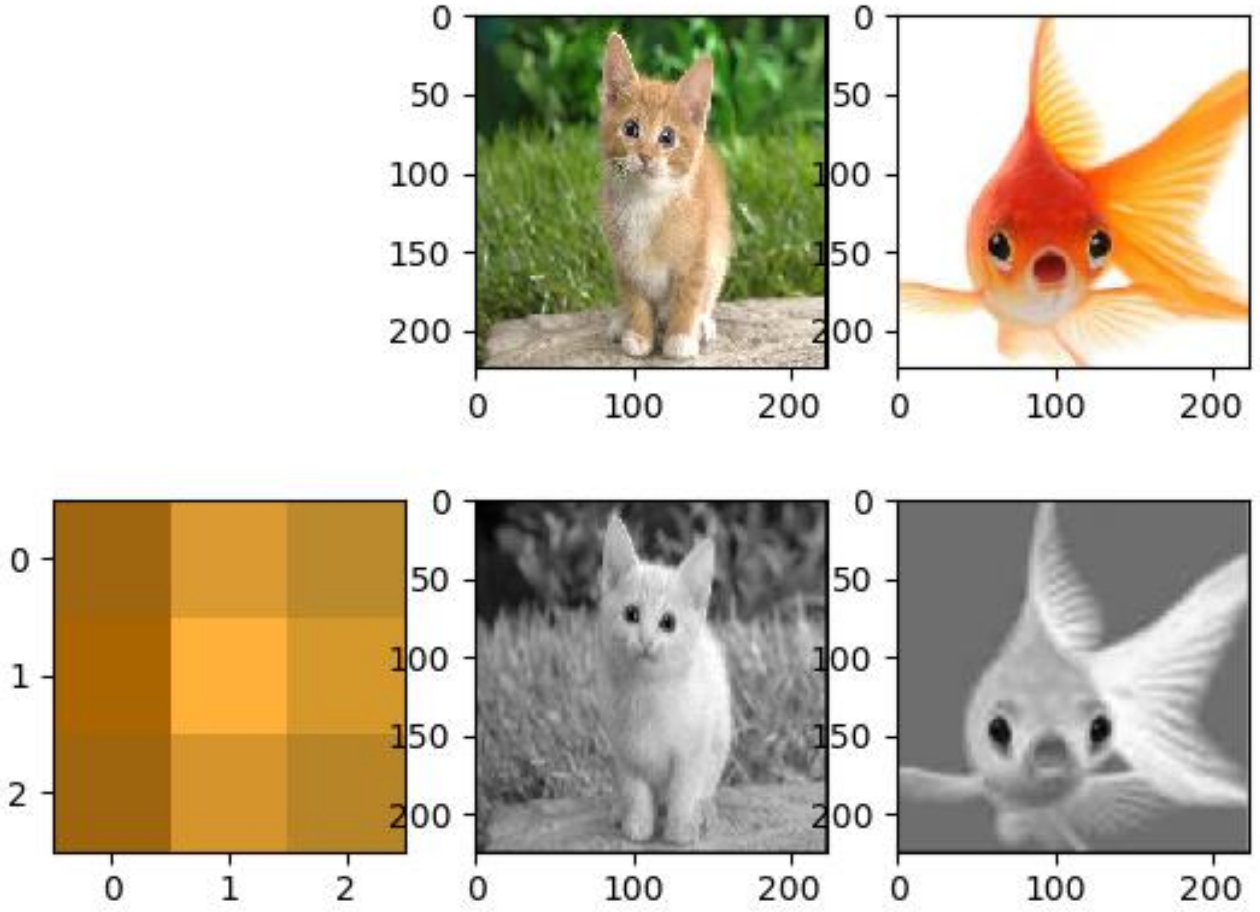
Filter 0/64: EDGE BASED FILTER



Given an image, observe the Activations for each layer

- Layer1

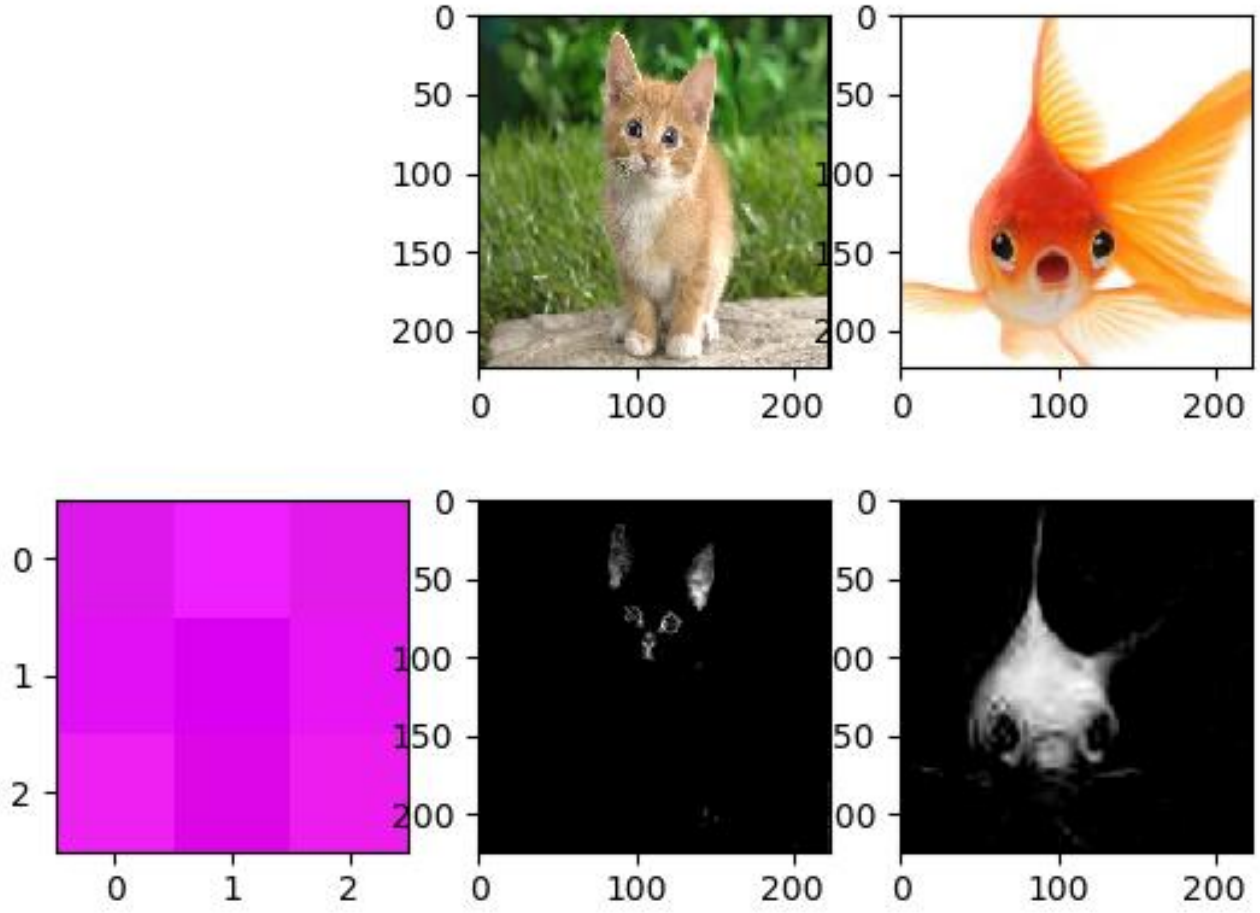
Filter 1/64: COLOR BASED FILTER



Given an image, observe the Activations for each layer

- Layer1

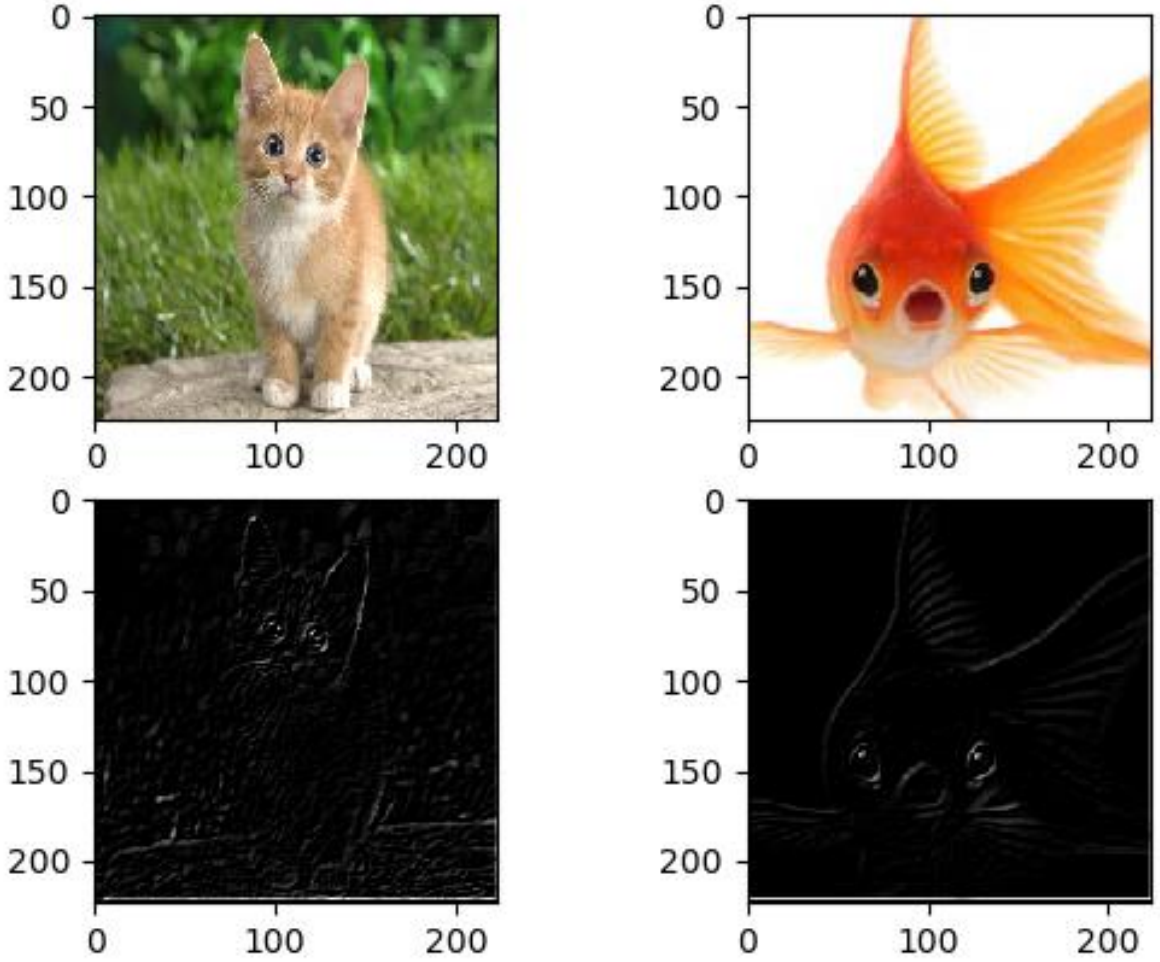
Filter 8/64: COLOR BASED FILTER



Given an image, observe the Activations for each layer

- Layer3

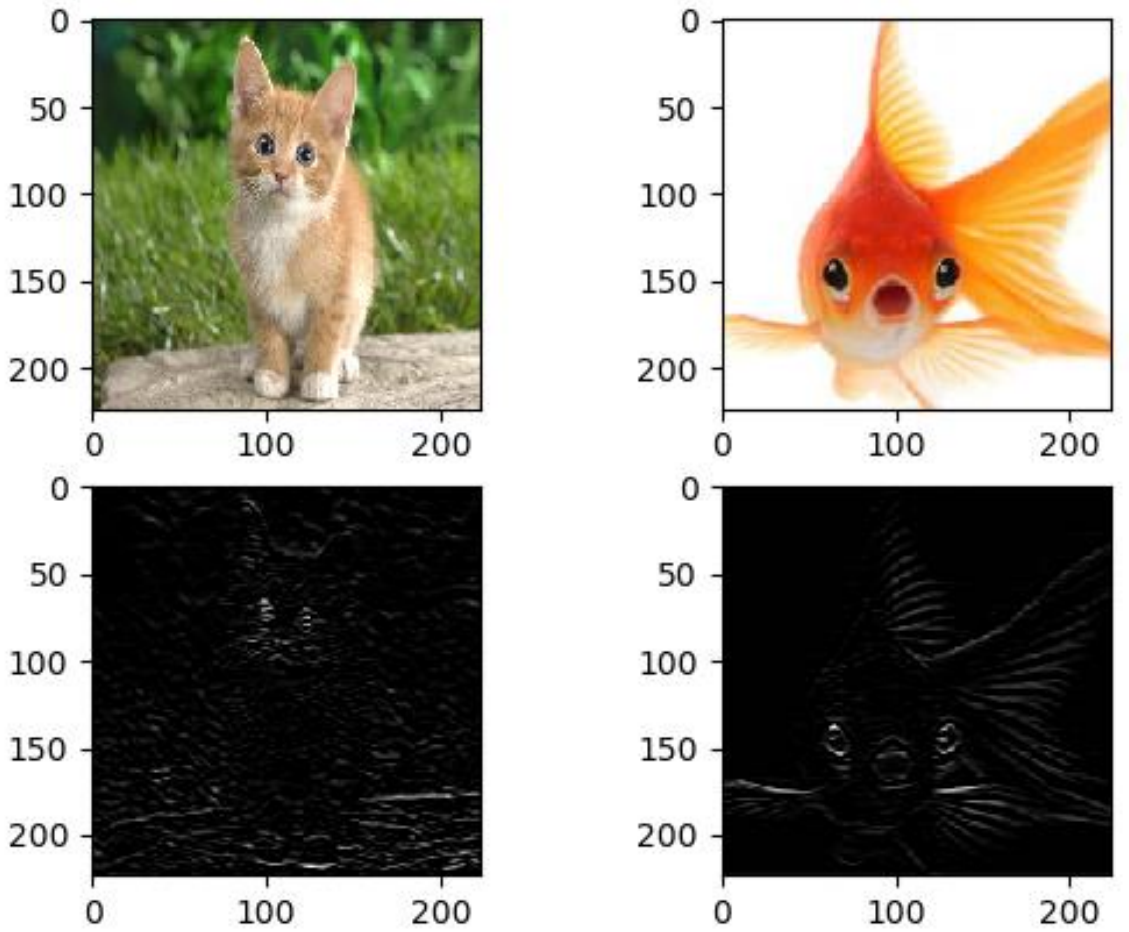
MULTI DIRECTION EDGES



Given an image, observe the Activations for each layer

- Layer3

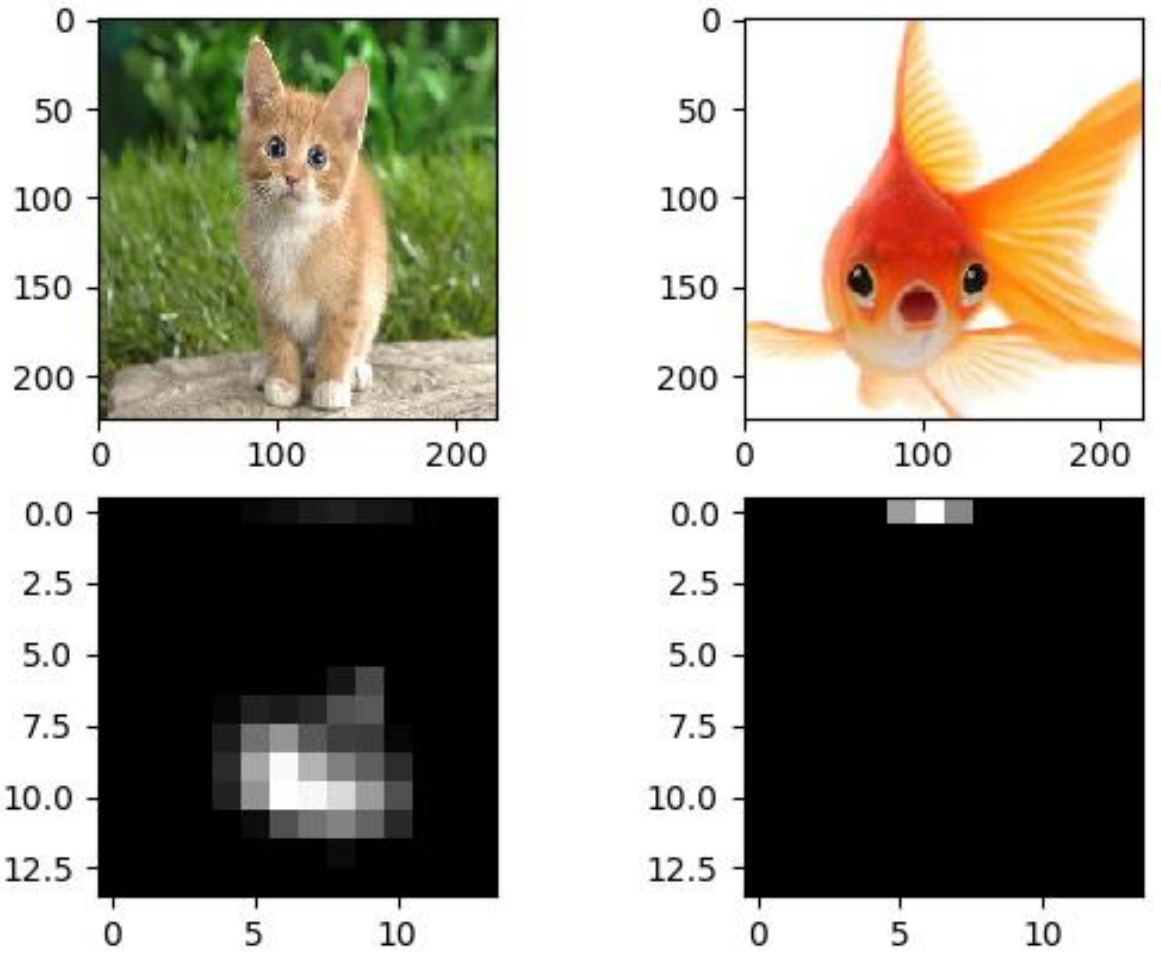
SINGLE DIRECTIONAL EDGES



Given an image, observe the Activations for each layer

- Layer35

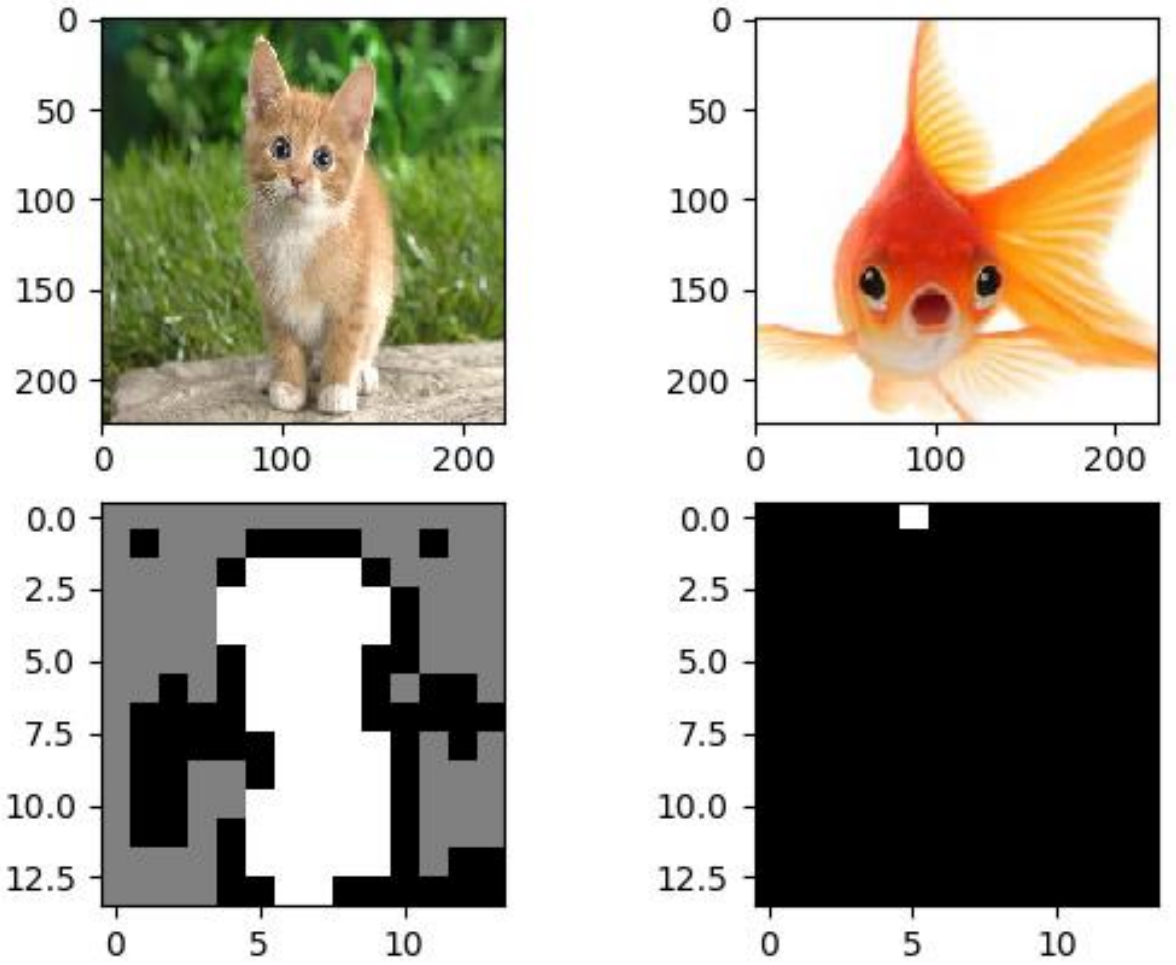
  Abstract



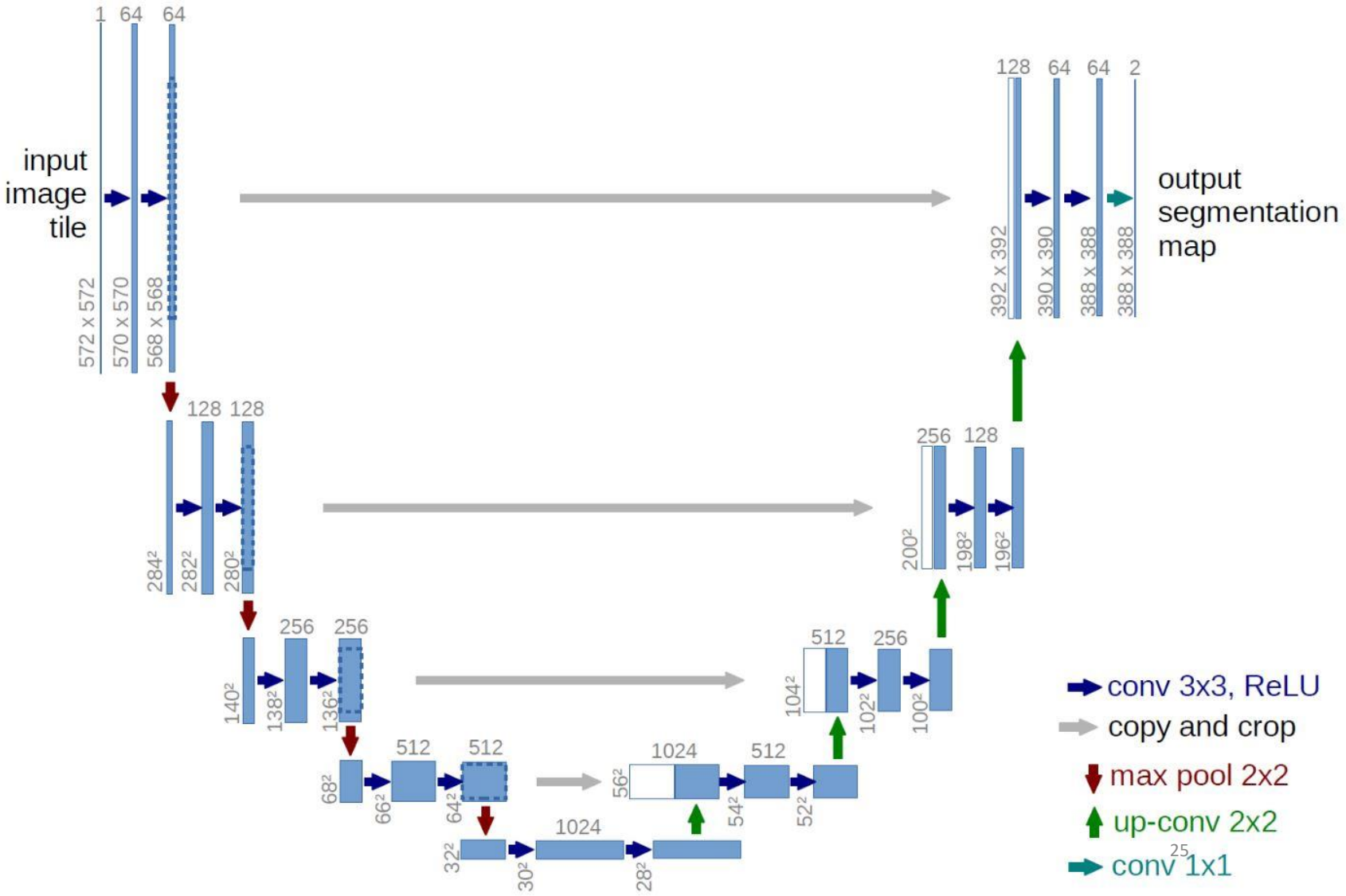
Given an image, observe the Activations for each layer

- Layer35

  Abstract

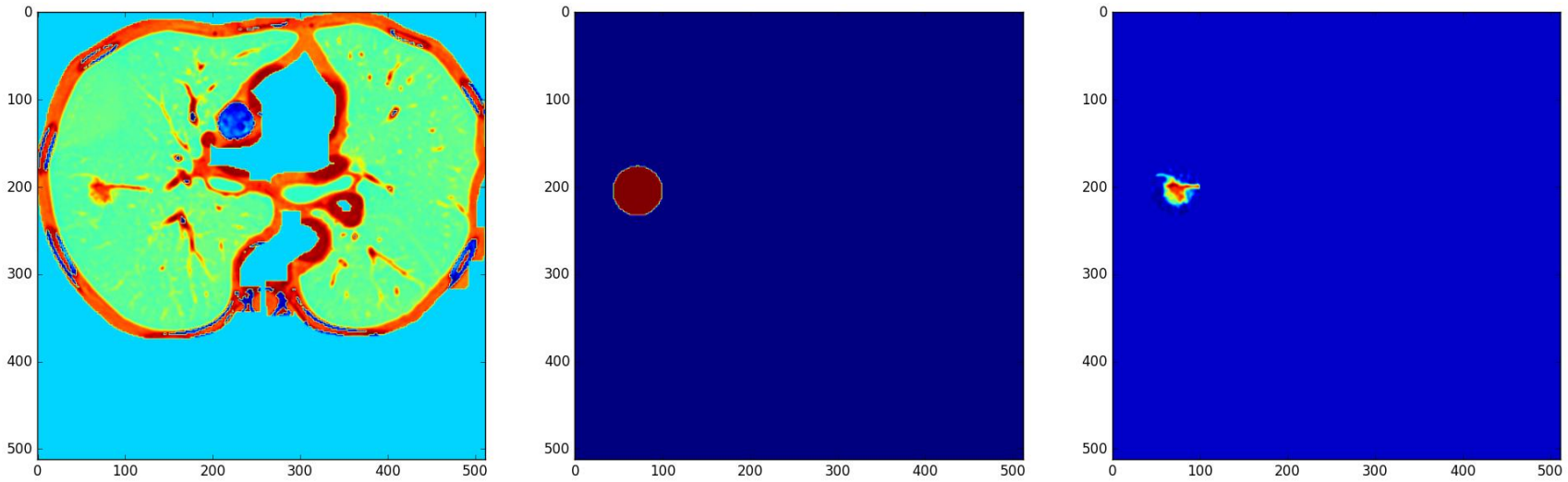


U-Net Segmentation

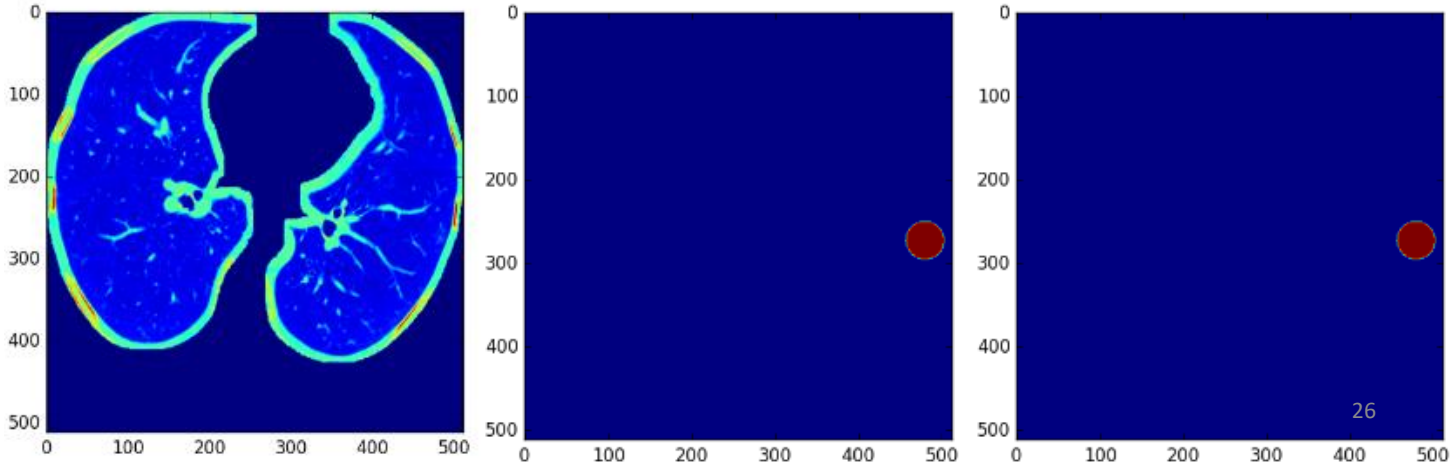


http://lmb.informatik.uni-freiburg.de/people/ronneber/u-net/

LUNA Dataset



Training Image: Training Label:



https://luna16.grand-challenge.org/

Now Lets Get into the Code..