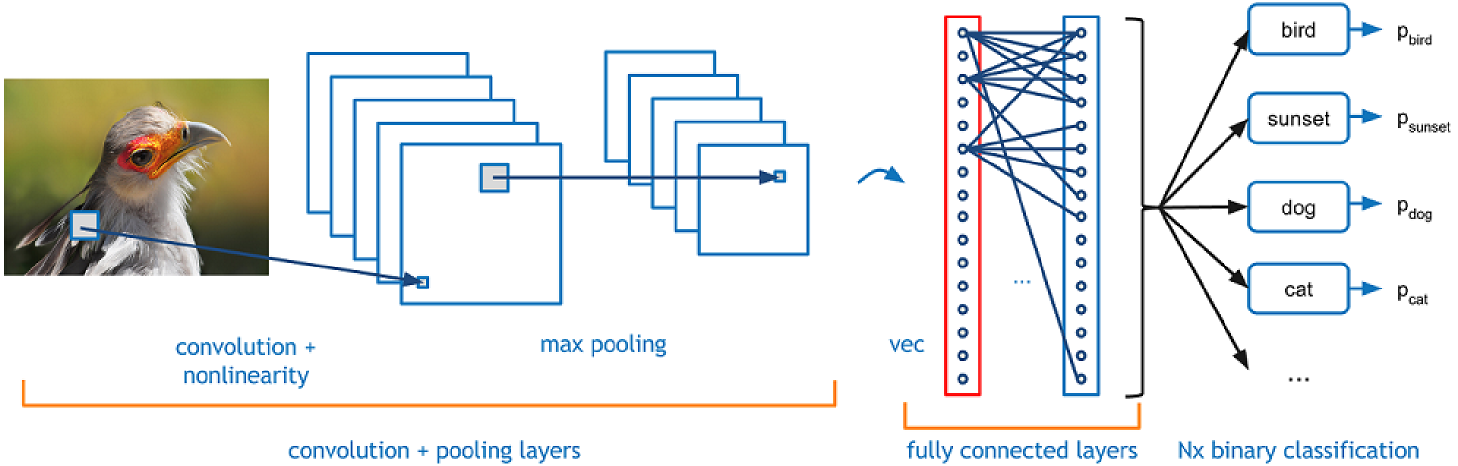
Basics for Convolutional Neural Network

CSE 455
Beibin Li
2020-05-26

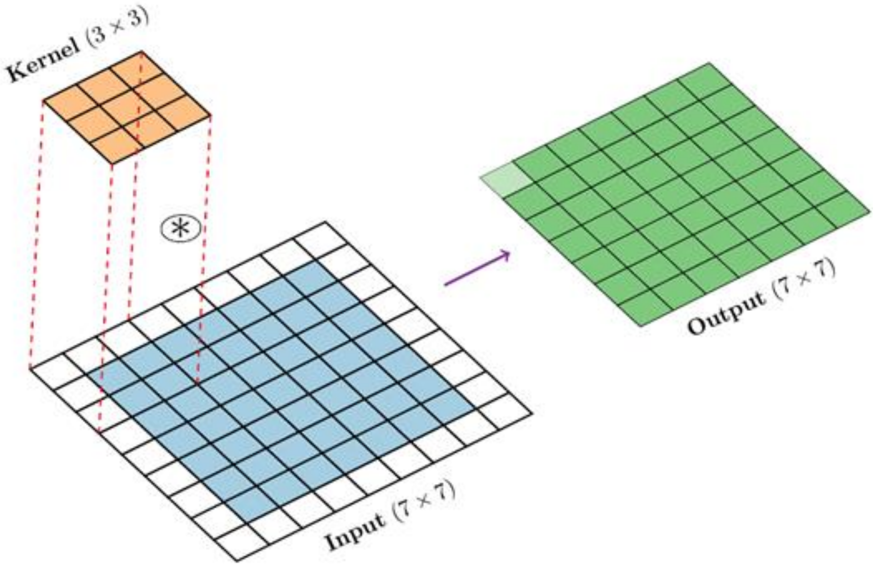
CNN

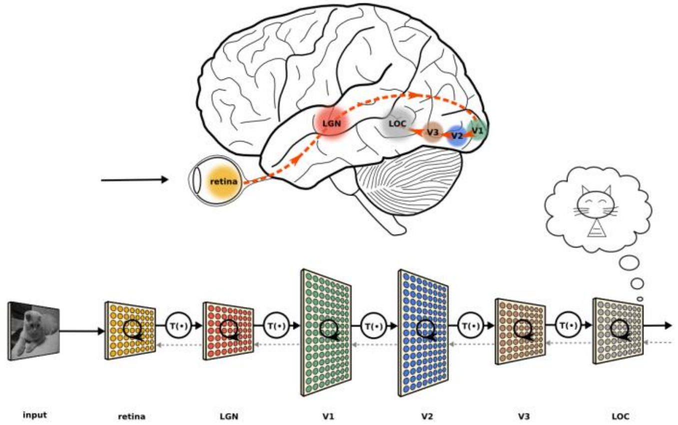


convolution +
nonlinearity
max pooling
vec
...
bird
sunset
dog
cat
...
p_bird
p_sunset
p_dog
p_cat
convolution + pooling layers
fully connected layers
Nx binary classification

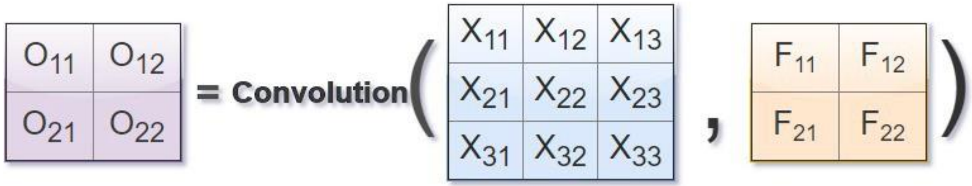
Convolution Operation

Nowadays, we learn kernels from the data.





Learning



$$O_{11} = F_{11}X_{11} + F_{12}X_{12} + F_{21}X_{21} + F_{22}X_{22}$$

$$O_{12} = F_{11}X_{12} + F_{12}X_{13} + F_{21}X_{22} + F_{22}X_{23}$$

$$O_{21} = F_{11}X_{21} + F_{12}X_{22} + F_{21}X_{31} + F_{22}X_{32}$$

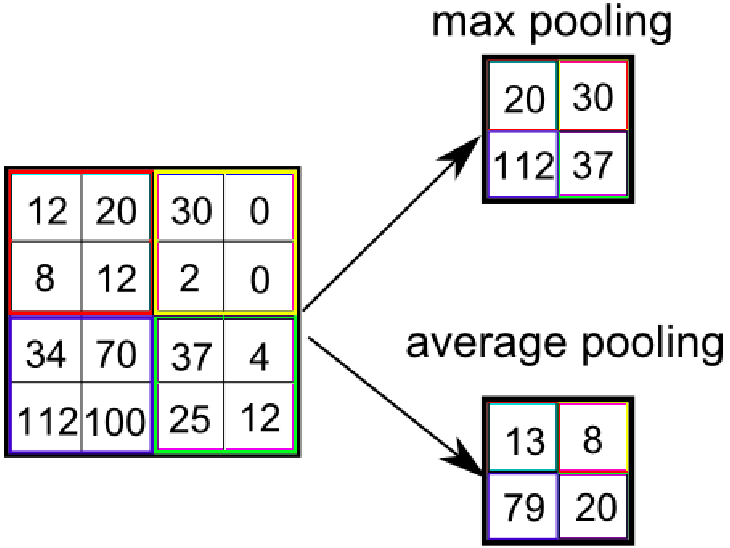
$$O_{22} = F_{11}X_{22} + F_{12}X_{23} + F_{21}X_{32} + F_{22}X_{33}$$

- Details:
- https://www.slideshare.net/EdwinEfranJimnezLepe/example-feedforward-backpropagation
- https://medium.com/@2017csm1006/forward-and-backpropagation-in-convolutional-neural-network-4dfa96d7b37e

Pooling

e.g. kernel size = 2, stride = 2 for both width and height.

The kernel size for pooling can be an even number.



CNN Structures

Image Classification

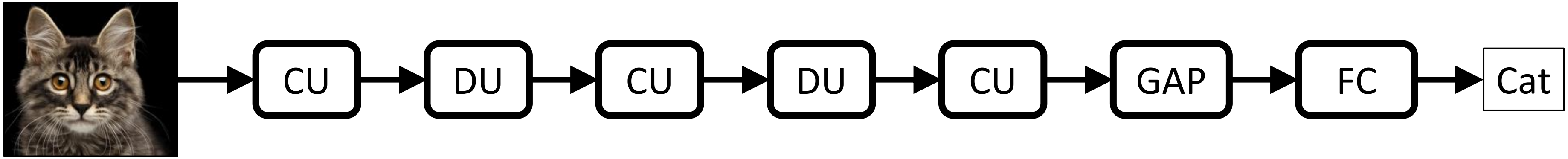
Image Classification

CU Convolutional Unit

FC Fully-connected Or Linear Layer

DU Down-sampling Unit

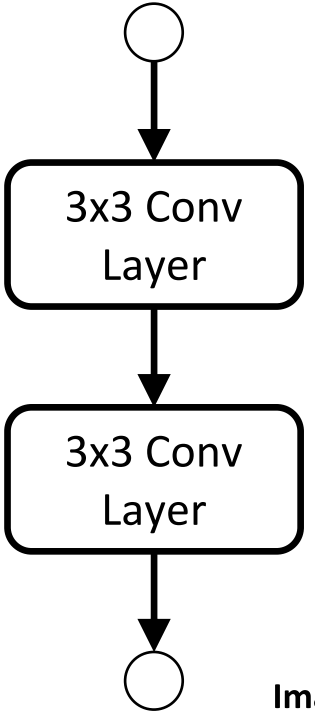
GAP Global Avg. Pooling

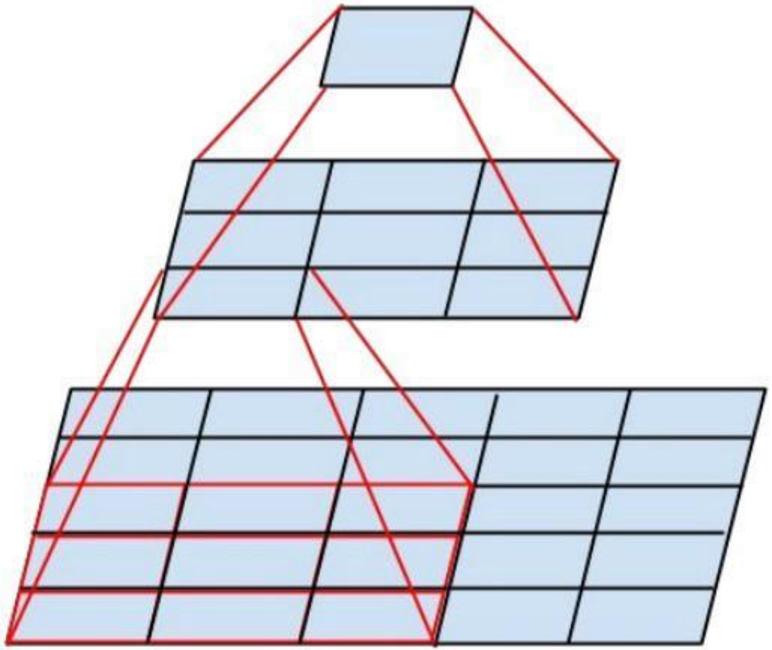


28 x 28 = $[28]^2$

$[28]^2$ $[14]^2$ $[14]^2$ $[7]^2$ $[7]^2$ $[1]^2$

Convolutional Unit (CU) - VGG





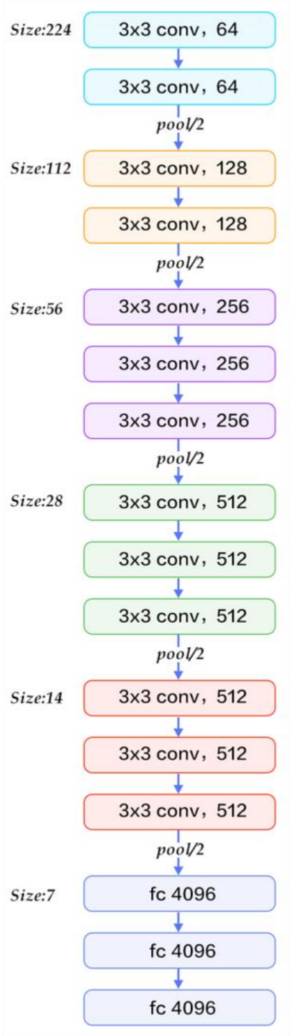
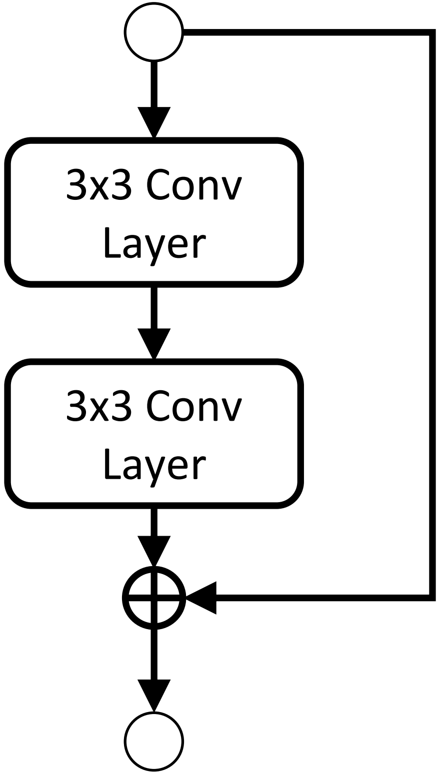


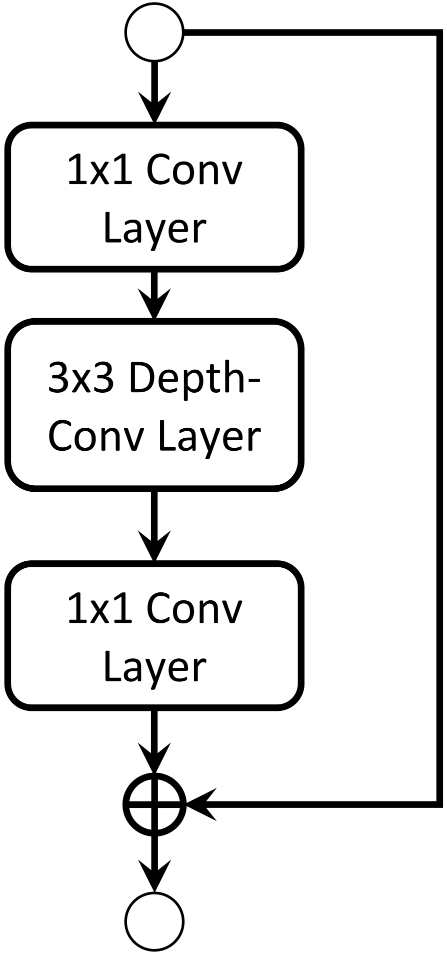
Image Source (Inception): Szegedy, Christian, et al. "Rethinking the inception architecture for computer vision." *CVPR*. 2016.

Basic Block in ResNet

ResNet: He, Kaiming, et al. "Deep residual learning for image recognition." CVPR. 2016.



- Residual Connection
- Element-wise addition of input and output
- Improves gradient flow and accuracy
- In ResNet-18 and ResNet-34
- Still computationally expensive
  - Hard to train very deep networks (> 100 layers)



Bottleneck in ResNet

- Used in ResNet-50, ResNet-101, ResNet-152, etc...
- Computationally Efficient

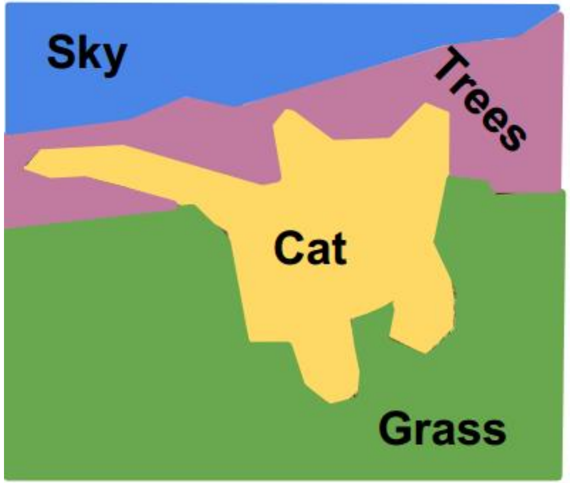
Influence:

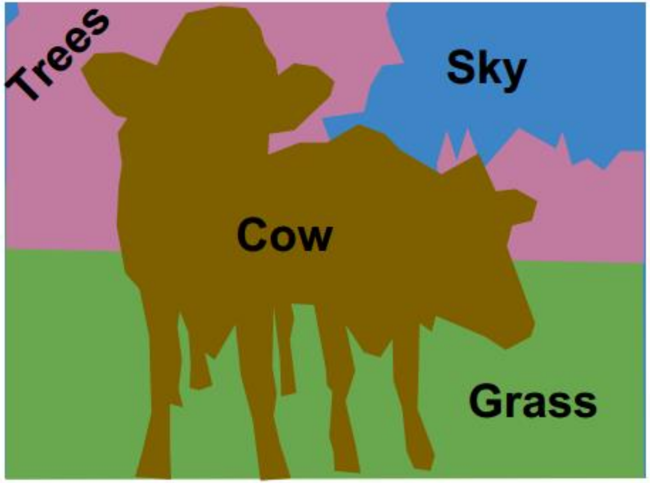
- Bottleneck unit with Depth-wise convs
  - MobileNetv2
  - ShuffleNetv2

- **MobileNetv2:** Sandler, Mark, et al. "Mobilenetv2: Inverted residuals and linear bottlenecks." CVPR, 2018.
- **ShuffleNetv2:** Ma, Ningning, et al. "Shufflenet v2: Practical guidelines for efficient cnn architecture design." ECCV, 2018.

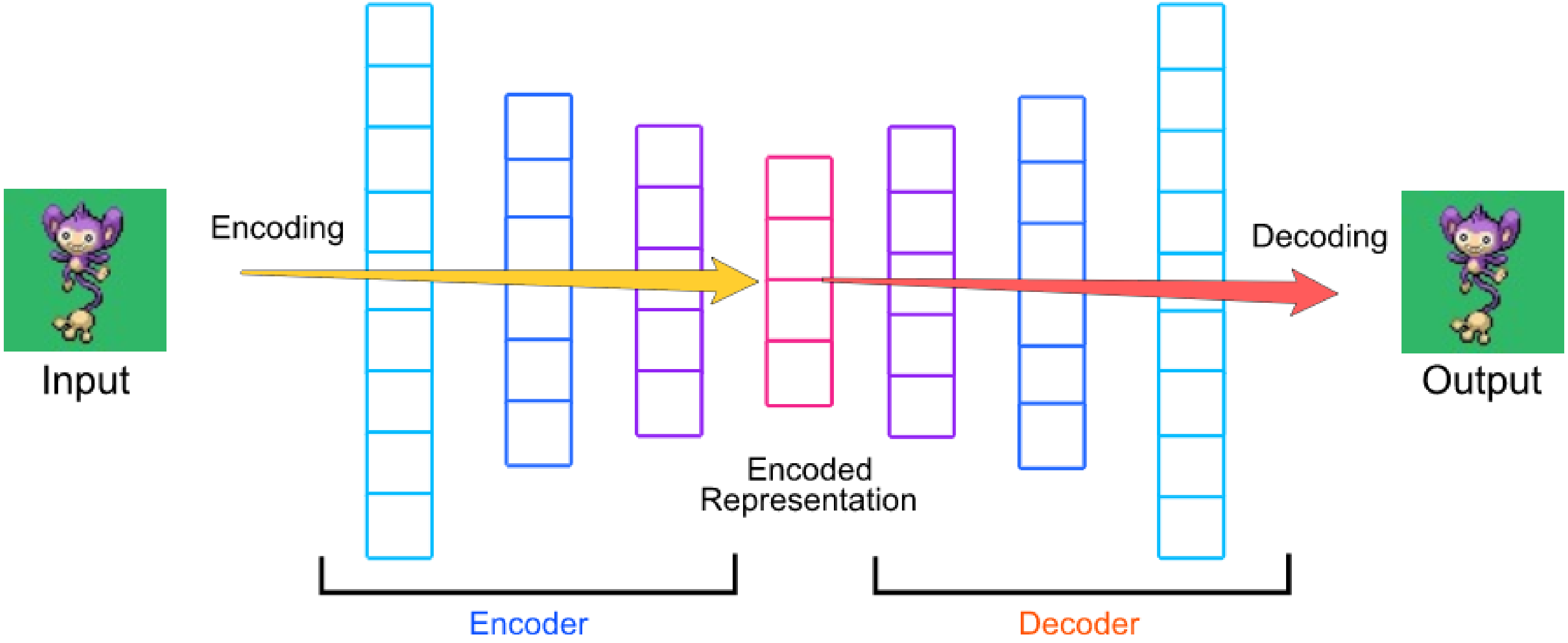
CNN Structures

Semantic Segmentation

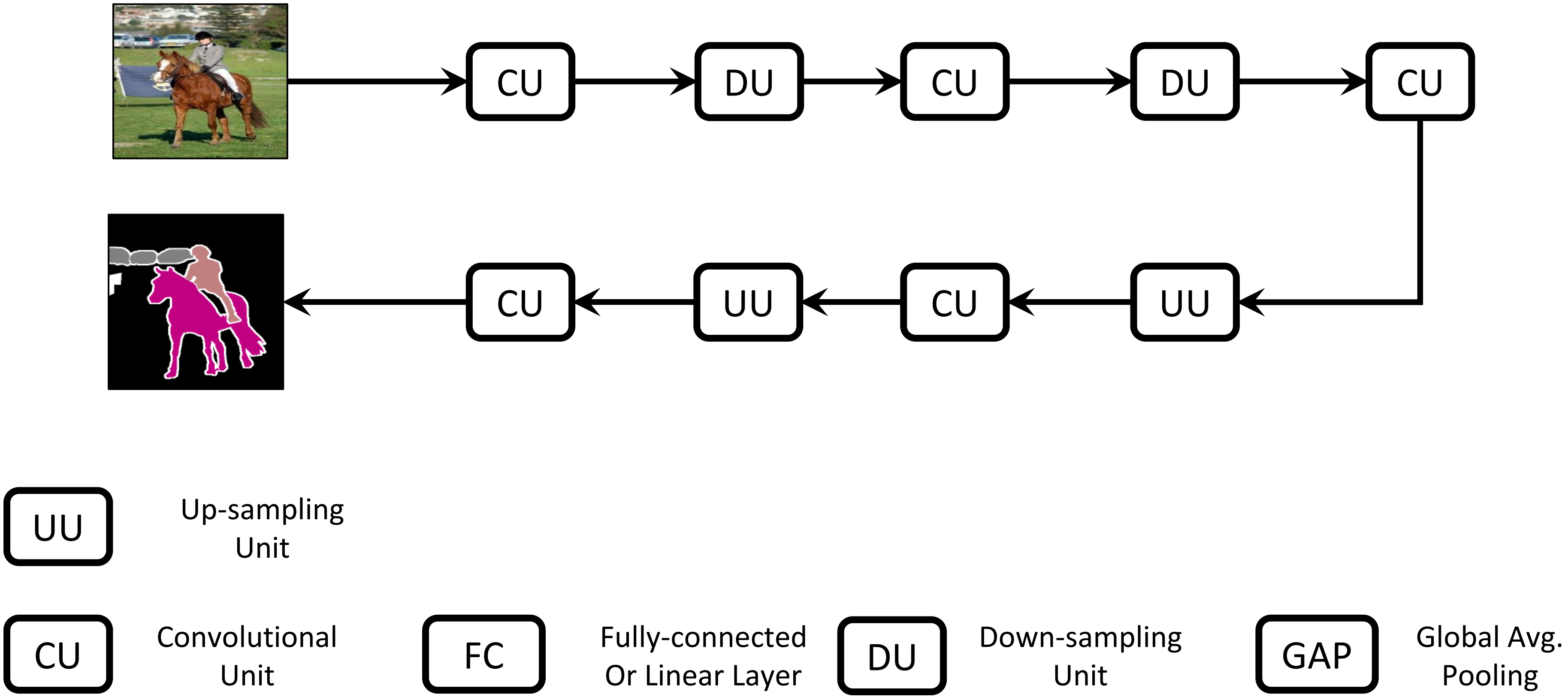

Sky
Trees
Cat
Grass


Trees
Sky
Cow
Grass

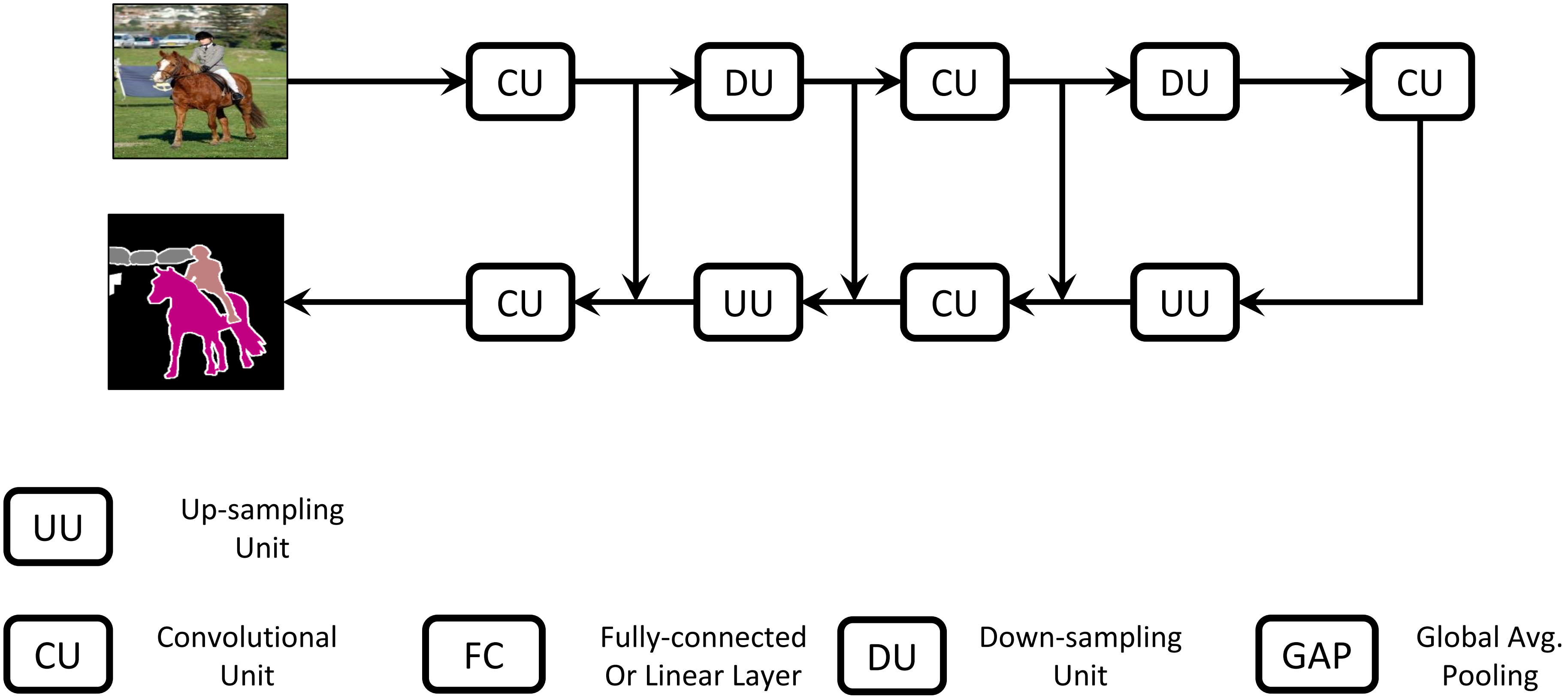
Encoder-Decoder



Encoder-Decoder in Semantic Segmentation



U-Net


CU
DU
CU
DU
CU
CU
UU
CU
UU
UU
Up-sampling
Unit
CU
Convolutional
Unit
FC
Fully-connected
Or Linear Layer
DU
Down-sampling
Unit
GAP
Global Avg.
Pooling

Deep Learning Libraries

mxnet

TensorFlow

theano

scikit learn

Caffe2

Keras

PYTORCH

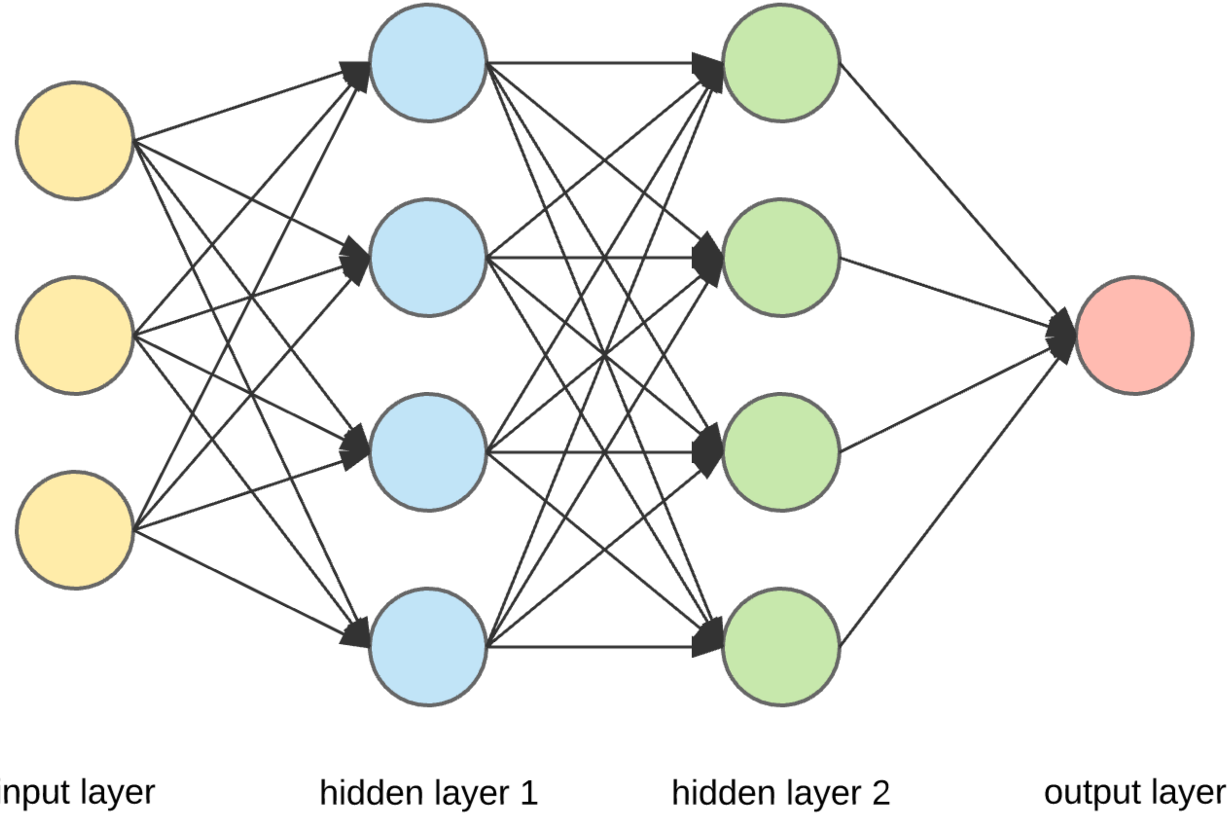
Homework 6

Homework 6
Convolutional Neural Networks
In PyTorch

(Optional Homework)

Due: June/4

Neural Network (Q1)



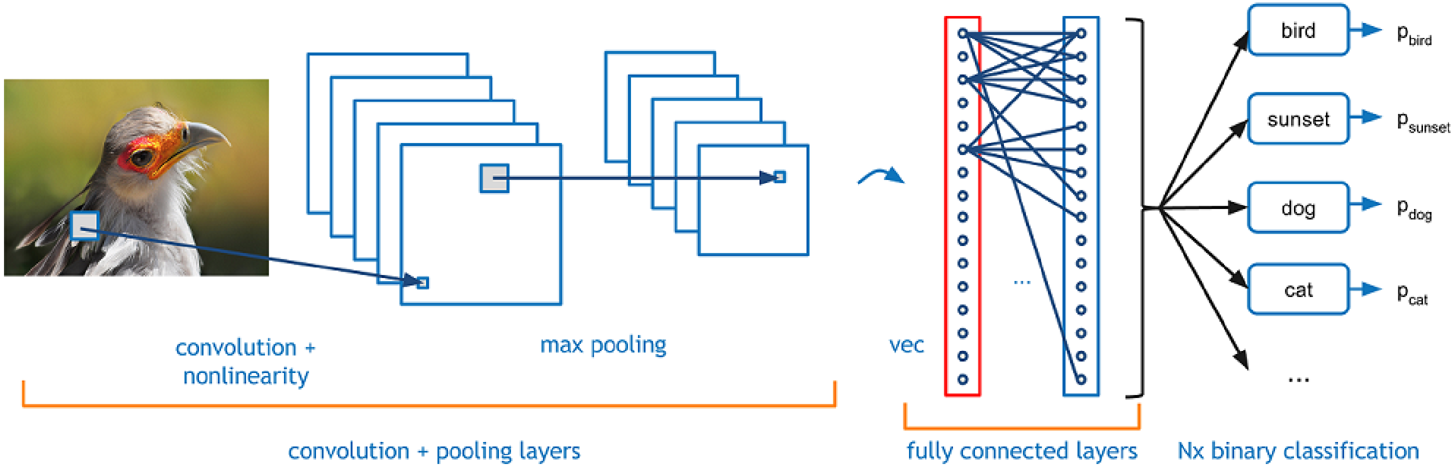
Convolutional Neural Network (Q2)

Conv

Pool

FC

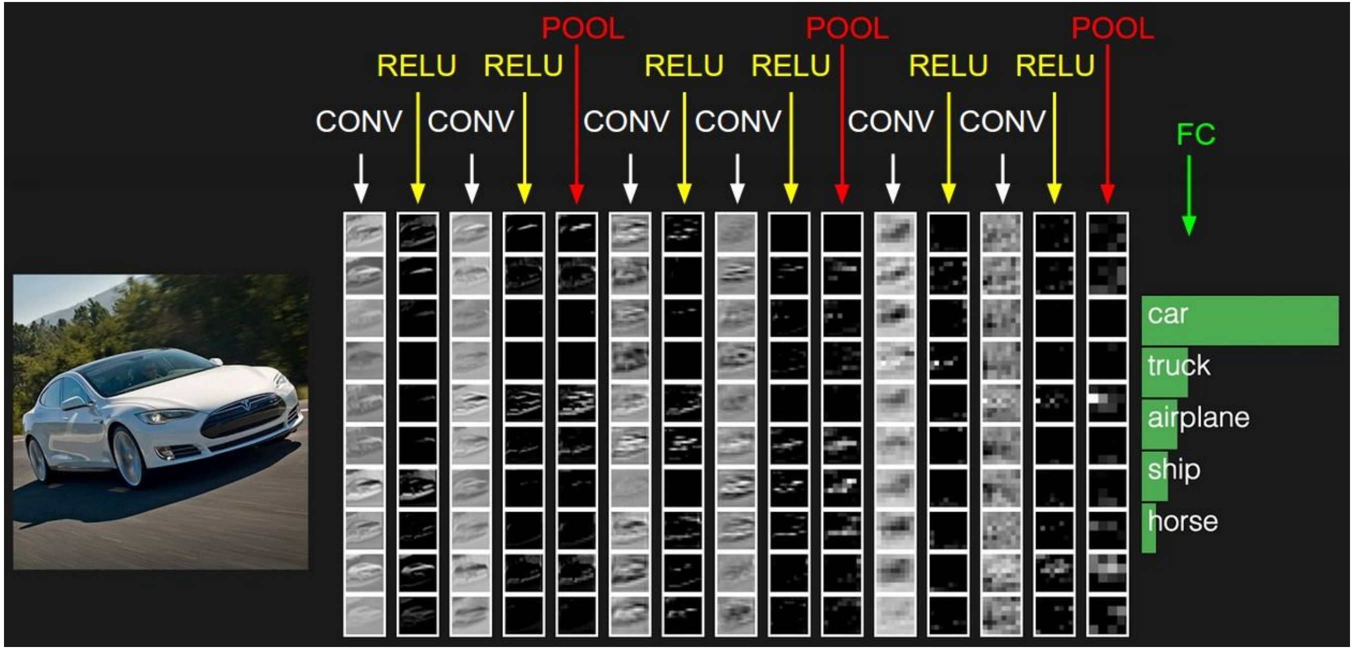
Cross Entropy



Yellow or Blue?

Color Normalization (Q3)

Deep Convolutional Neural Network (Q4)



Make the Design More Flexible

Input:

[8, 16, 32, "pool"]

Layer	Output Size	Output Channels
Input	30 x 30	3
Conv	28 x 28	8
ReLU	28 x 28	8
Conv	26 x 26	16
ReLU	26 x 26	16
Conv	24 x 24	32
ReLU	24 x 24	32
Max Pool	12 x 12	32
Linear	5	

Data Augmentation (Q5)

Random Affine Transformation