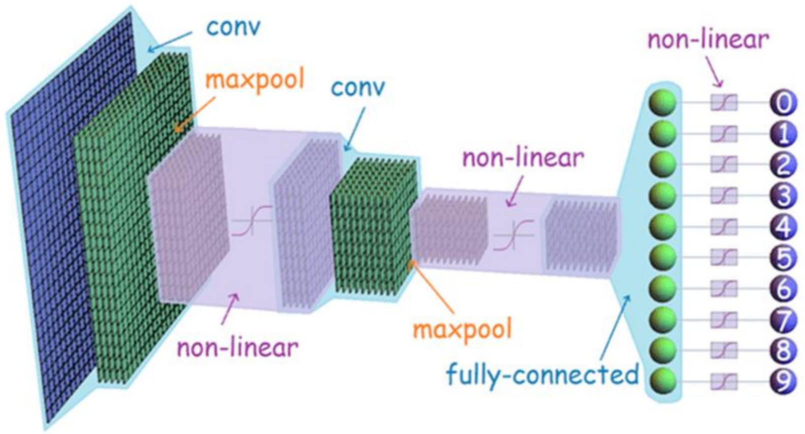
Deep Learning Workshop

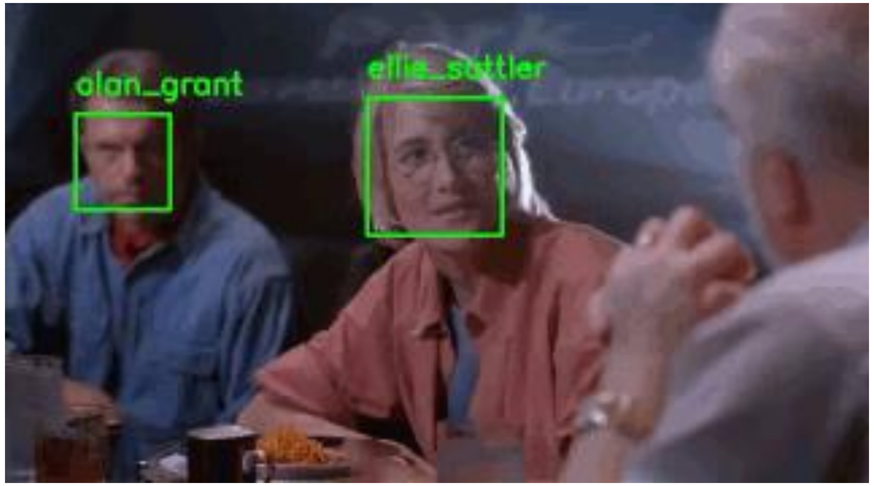
Convolutional Neural Networks



Instructor: Aaron Low

HELP University, Faculty of Computing and Digital Technology

Computer Vision



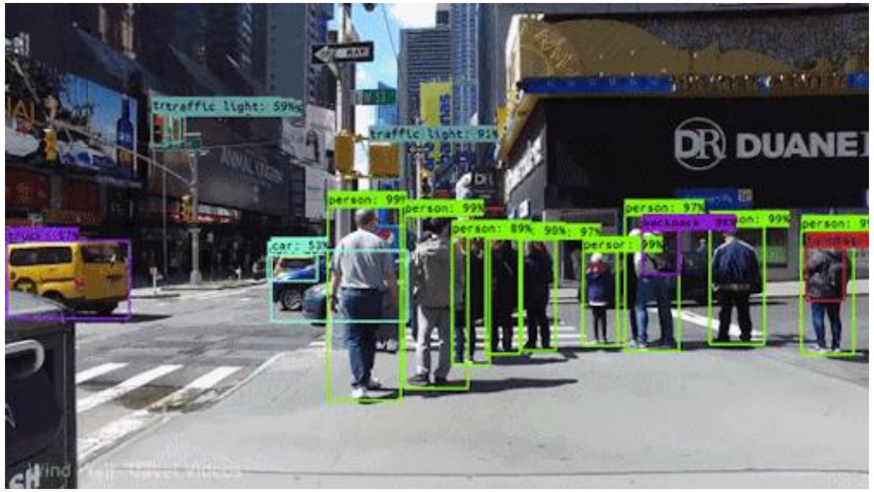


Image Representation

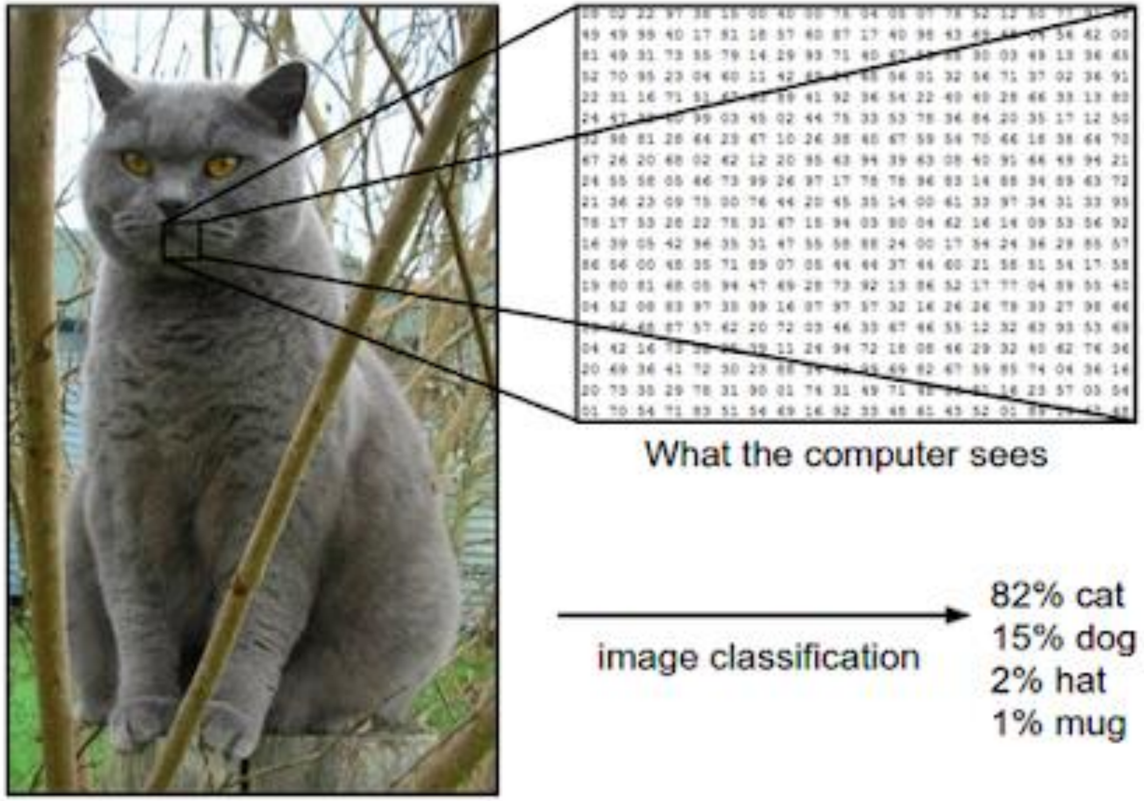
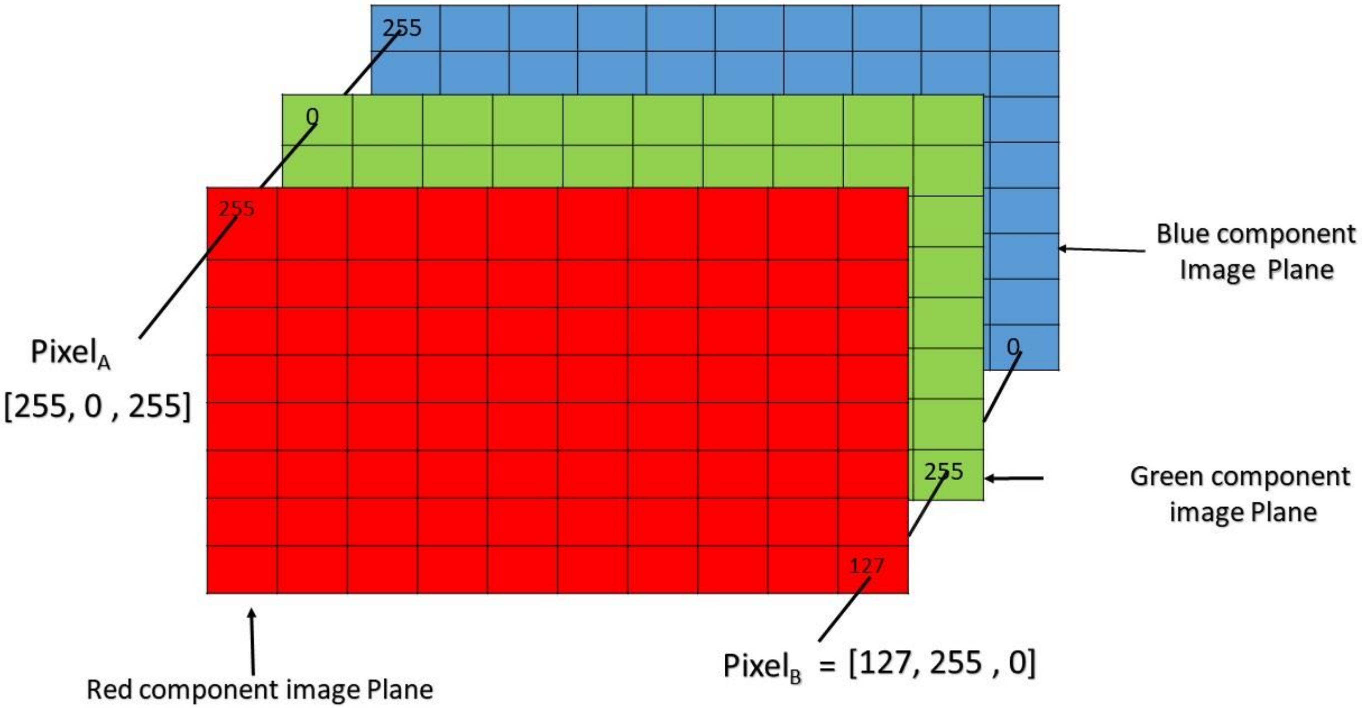
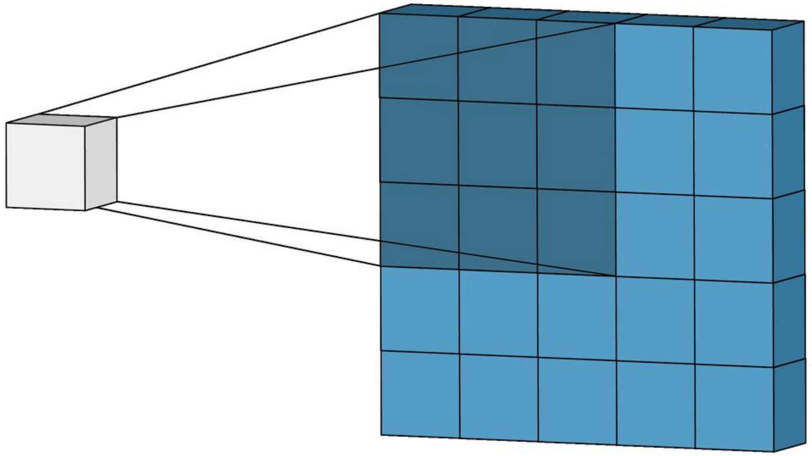


Image Representation



1: Image taken from https://www.geeksforgeeks.org/matlab-rgb-image-representation/

Convolution Operation

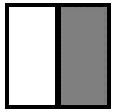


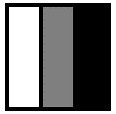
Convolutional Layer GIF from https://blog.usejournal.com/convolutional-neural-networks-why-what-and-how-f8f6dbebb2f9?gi=3faa9b8cfe4c

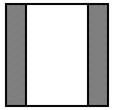
Convolution Operation: Edge Detection

Filter or Kernel

$$
\begin{bmatrix} 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \end{bmatrix} * \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} = \begin{bmatrix} 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \end{bmatrix}
$$





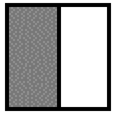


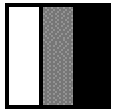
Convolution image from http://datahacker.rs/edge-detection-extended/

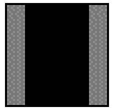
Convolution Operation: Edge Detection

Filter or Kernel

$$
\begin{bmatrix} 0 & 0 & 0 & 10 & 10 & 10 \\ 0 & 0 & 0 & 10 & 10 & 10 \\ 0 & 0 & 0 & 10 & 10 & 10 \\ 0 & 0 & 0 & 10 & 10 & 10 \\ 0 & 0 & 0 & 10 & 10 & 10 \\ 0 & 0 & 0 & 10 & 10 & 10 \end{bmatrix} * \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} = \begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}
$$



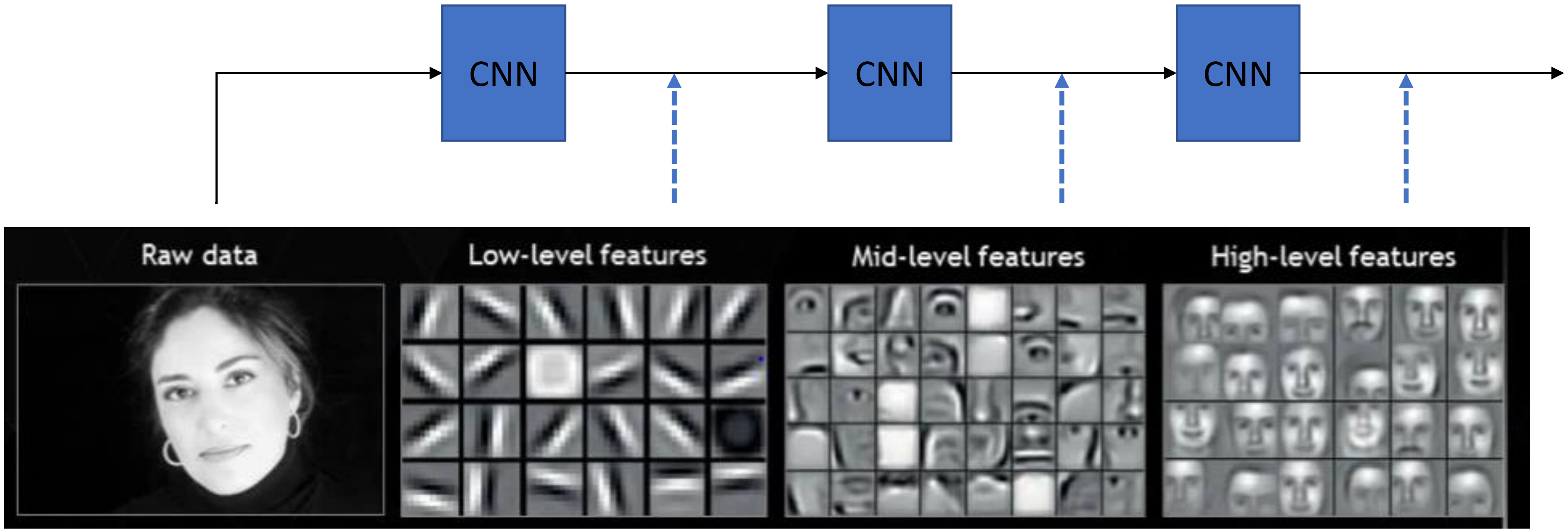




Convolution image from http://datahacker.rs/edge-detection-extended/

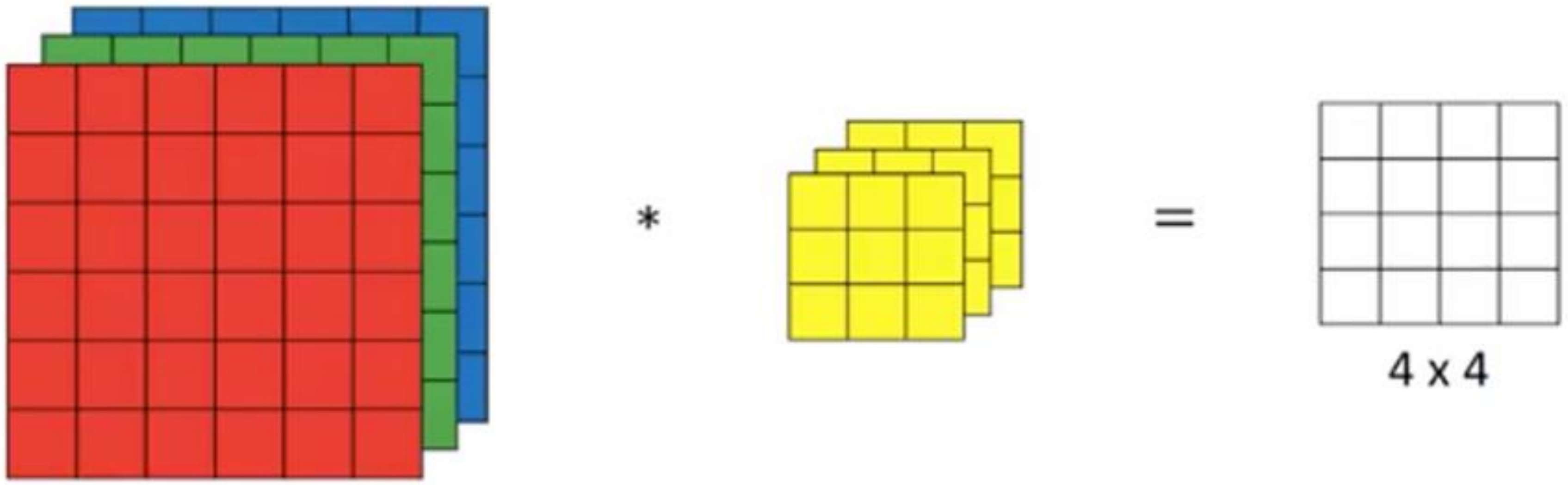
Feature Learning

- Deep Learning is **Representation/Feature Learning**

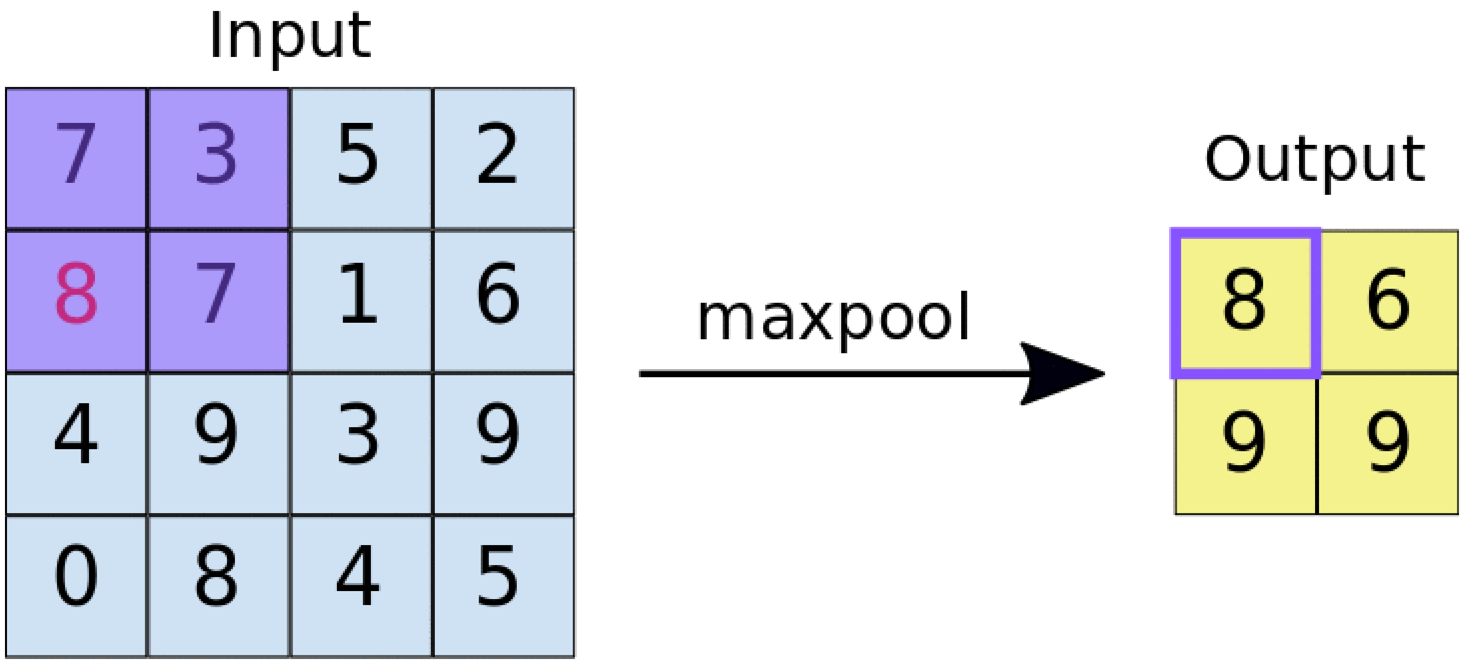


Convolutional Neural Network: Convolutional Layer

- No need to hand choose filters just **learn the correct weights**

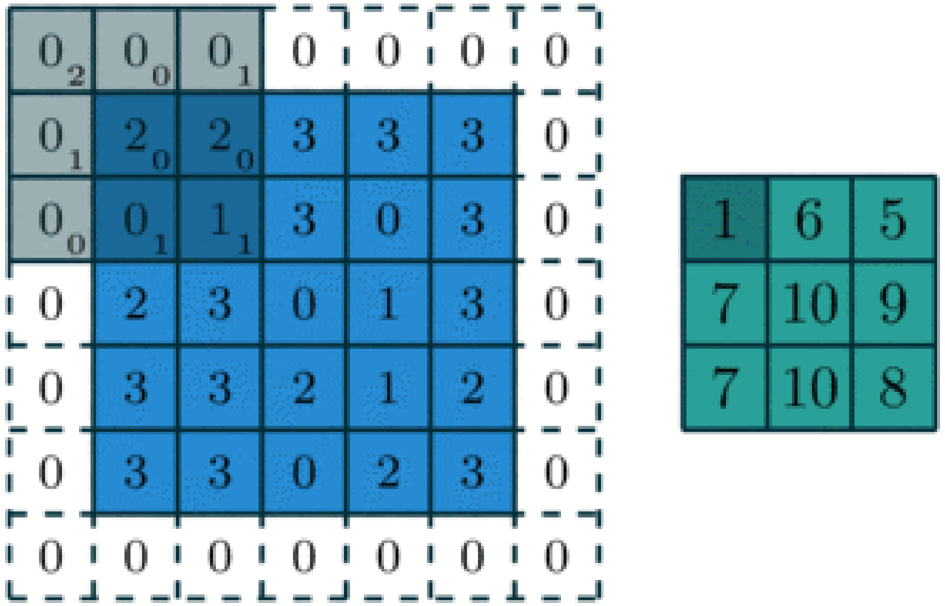


Convolutional Neural Networks: Max Pool



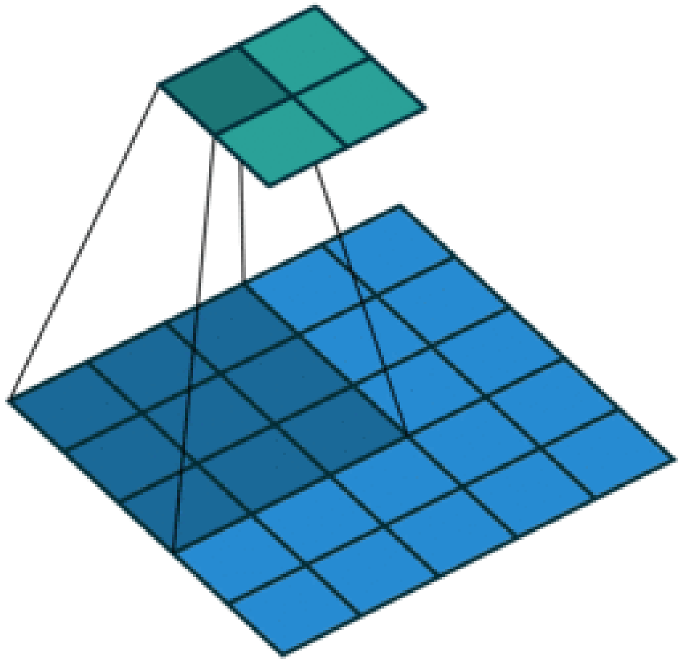
Max Pool layer from https://developers.google.com/machine-learning/practica/image-classification/convolutional-neural-networks

Convolutional Neural Networks: Padding



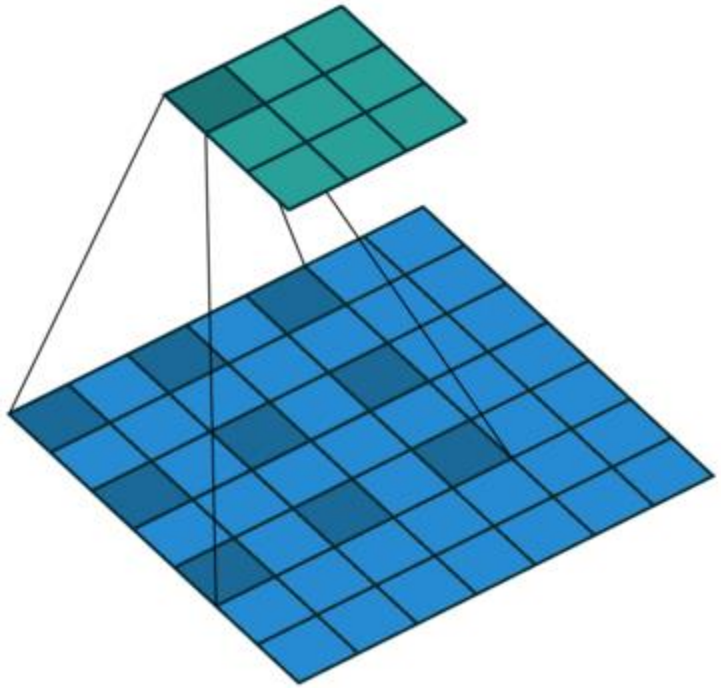
Padding gif from http://deeplearning.net/software/theano/tutorial/conv_arithmetic.html

Convolutional Neural Networks: Strided Convolution



Strided convolution gif from http://deeplearning.net/software/theano/tutorial/conv_arithmetic.html

Convolutional Neural Networks: Dilated Convolution



Dilated convolution gif from http://deeplearning.net/software/theano/tutorial/conv_arithmetic.html

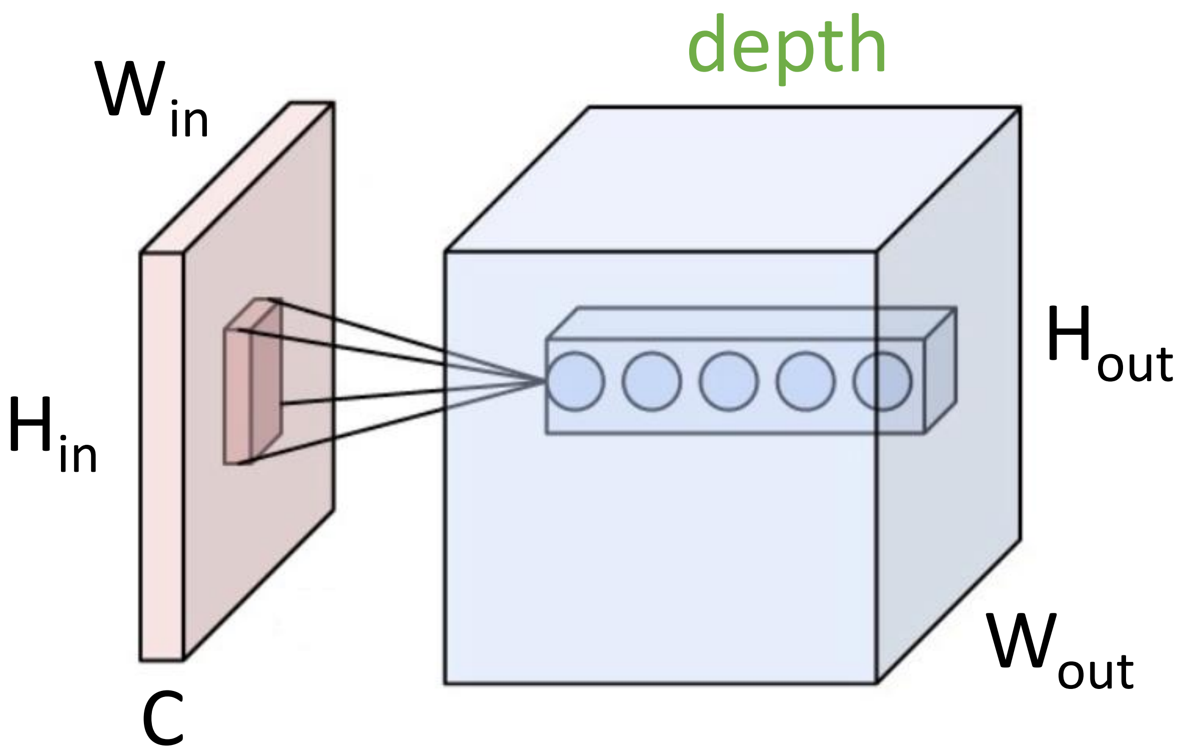
Convolution Output

$$H_{out} = \frac{H_{in} + 2 \text{ x padding[0]} - \text{kernel\_size[0]}}{stride[0]} + 1$$

$$W_{out} = \frac{W_{in} + 2 \text{ x padding[1]} - \text{kernel\_size[1]}}{stride[1]} + 1$$

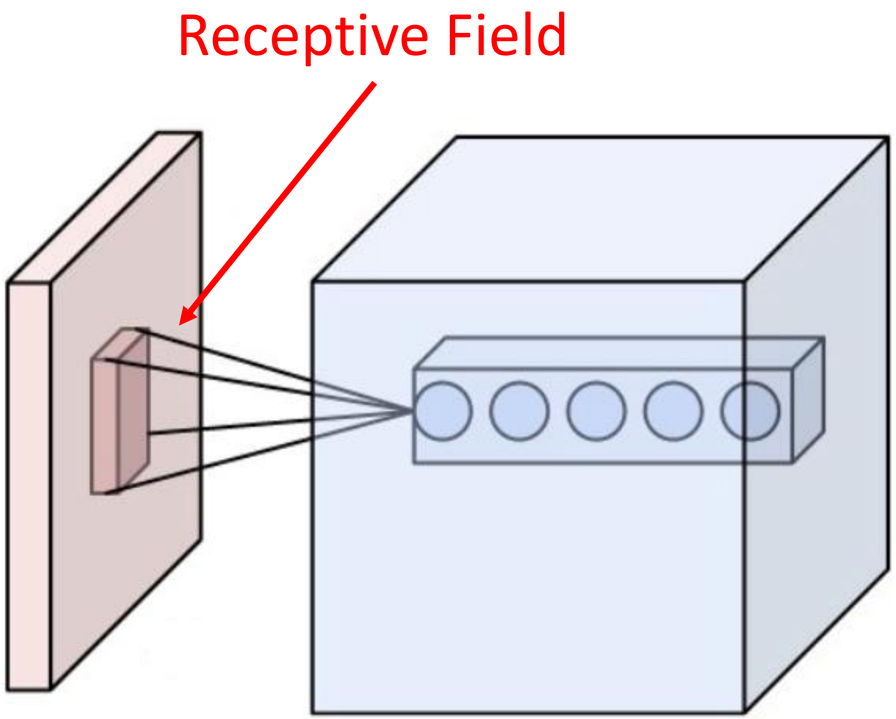
1: This is only a partial formula, not taking into account dilation. Full formula can be found at https://pytorch.org/docs/stable/nn.html#conv2d

Convolution Output



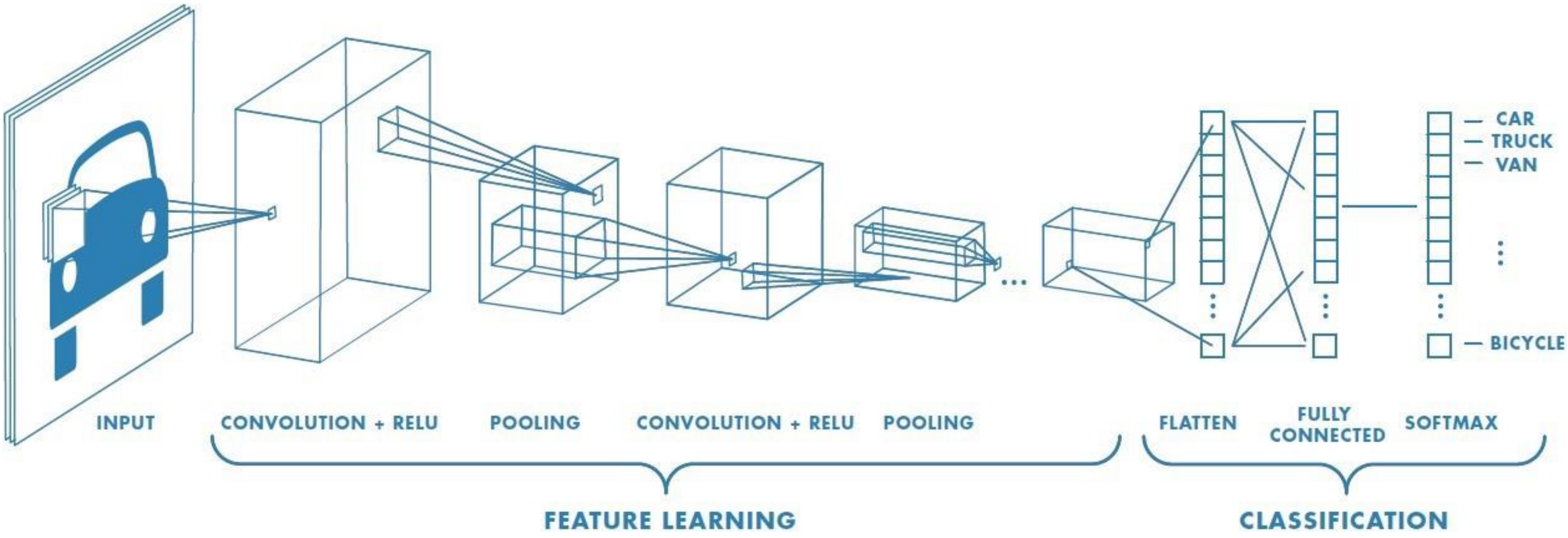
- H_{out} and W_{out} given by the previous formula
- depth given by number of filters (can be any number decided by user)

Receptive Field



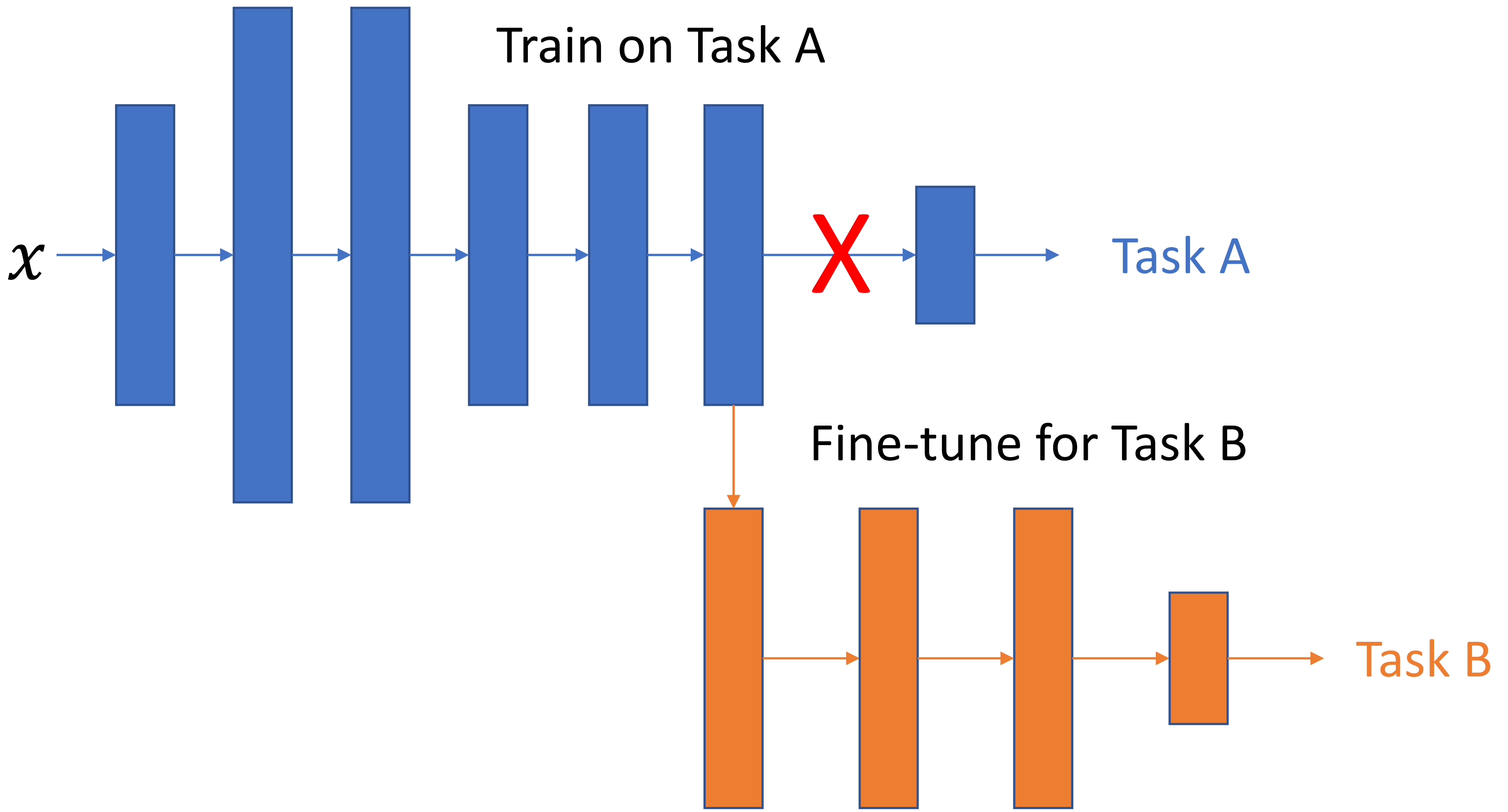
- The key parameter to associate an output feature to an input region is the of the convolutional network
- The size of the region in the input that produces the feature

Convolutional Neural Networks: Putting it all together

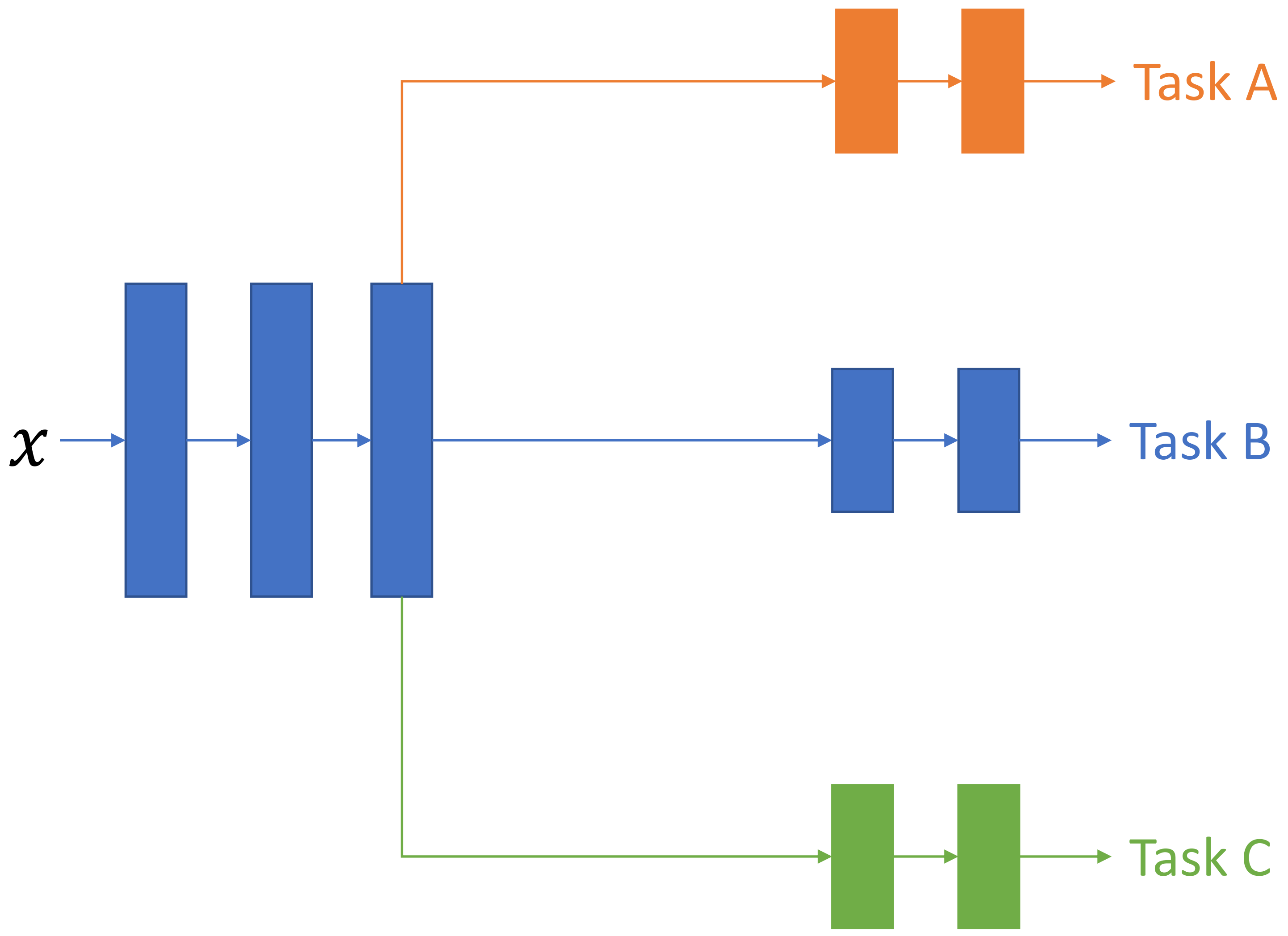


Convolutional Network from https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

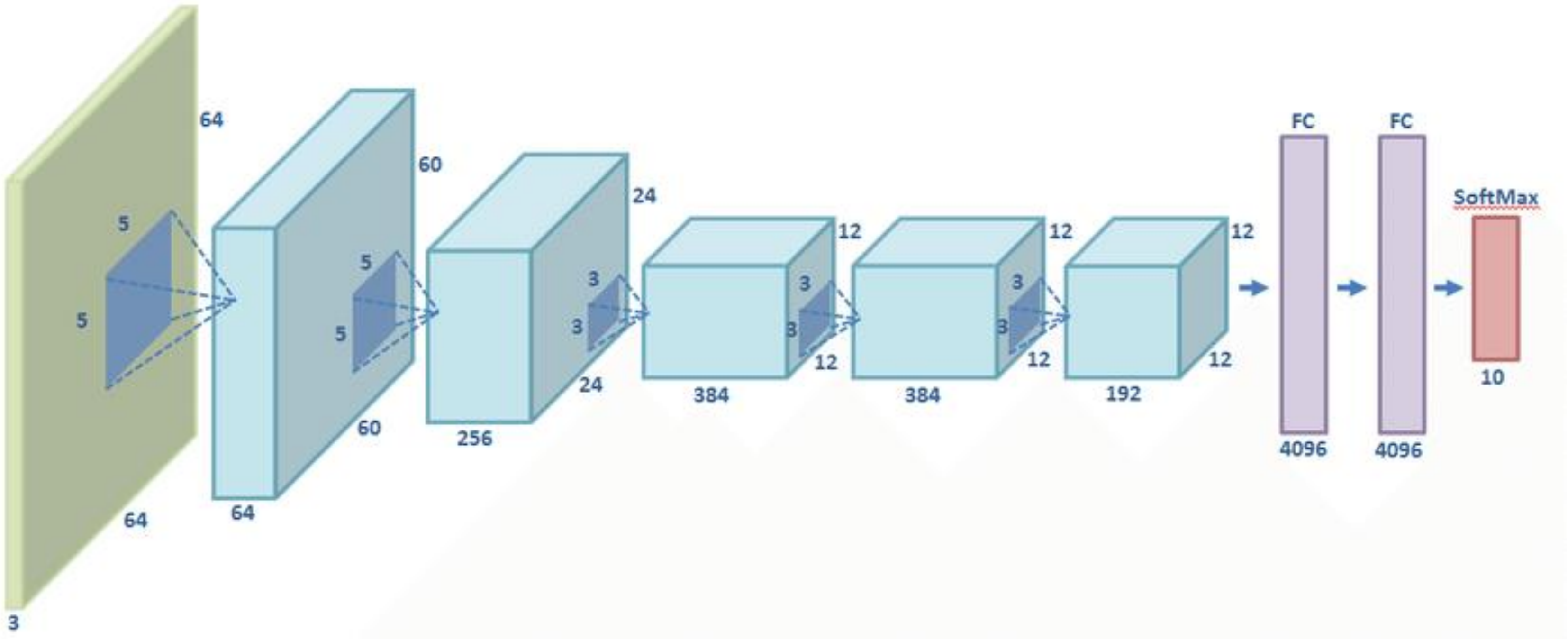
Transfer Learning



Multitask Learning

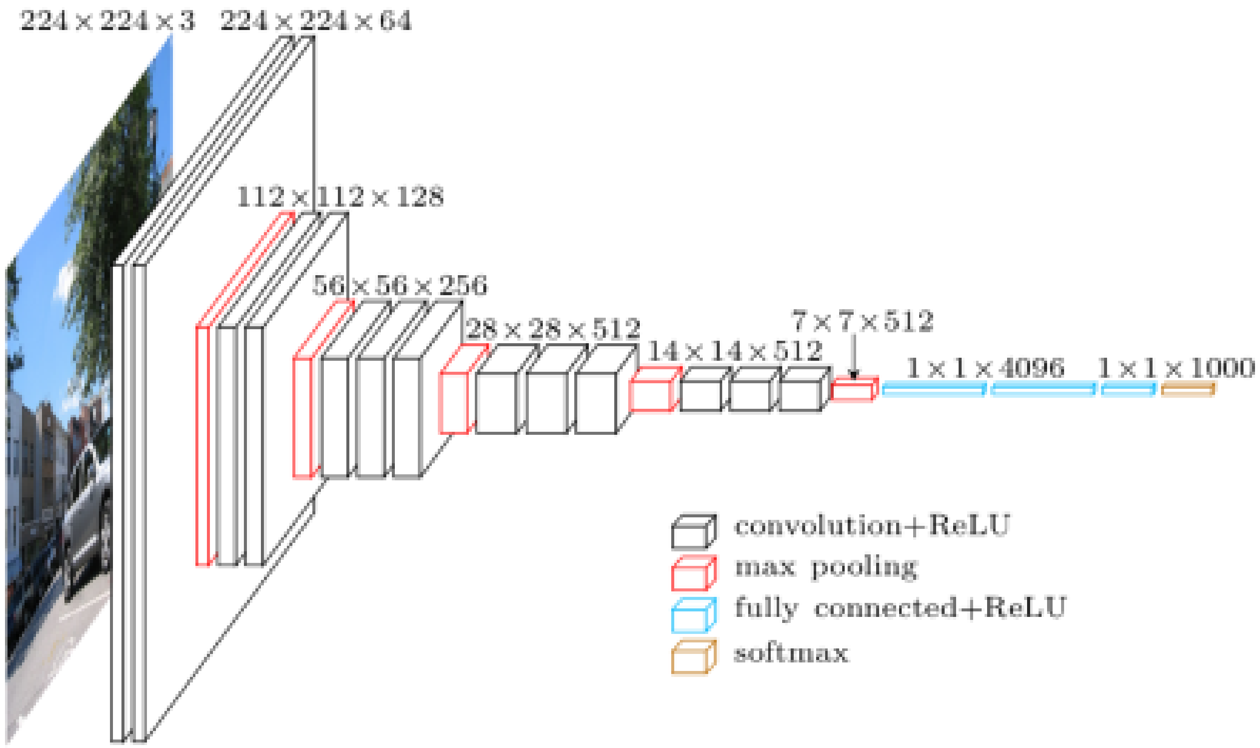


Popular Conv Net: AlexNet



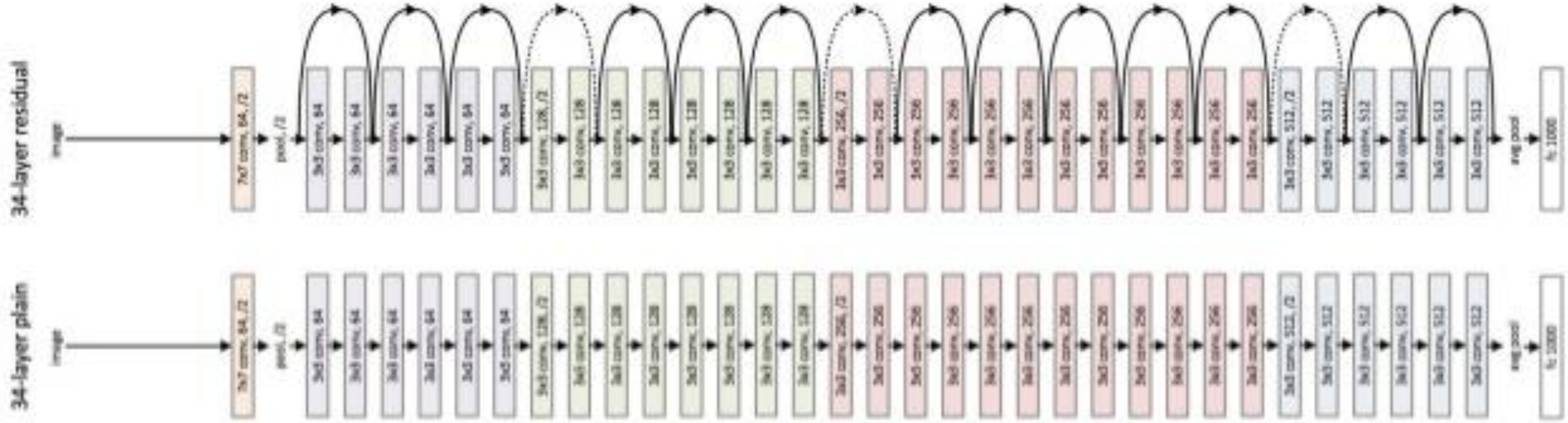
Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." Advances in neural information processing systems. 2012.

Popular Conv Net: VGG



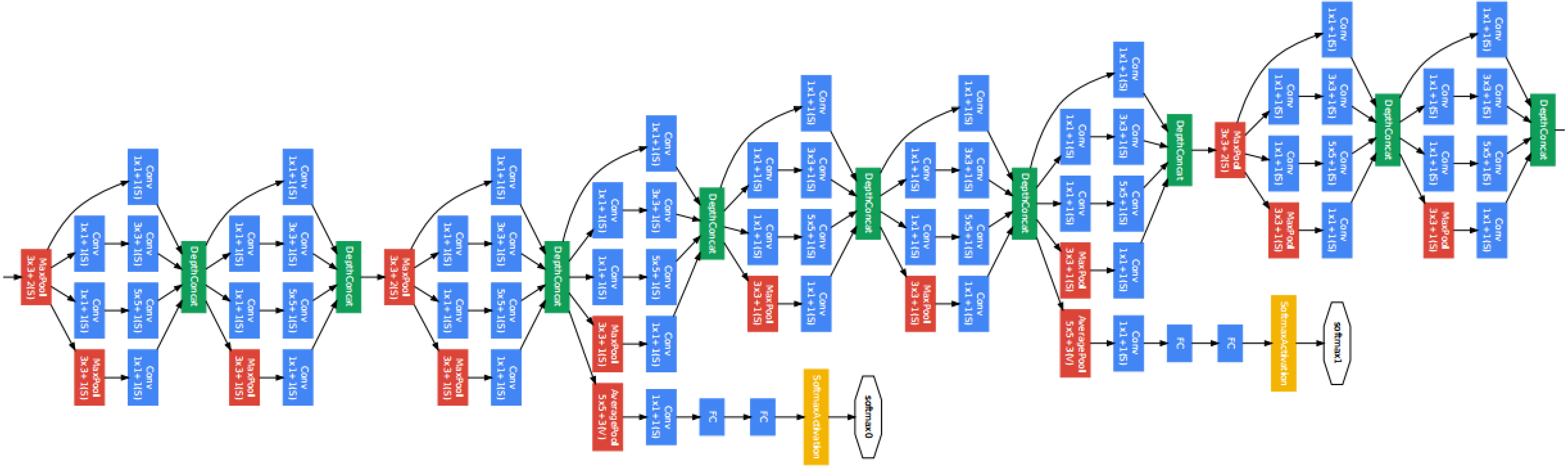
Simonyan, Karen, and Andrew Zisserman. "Very deep convolutional networks for large-scale image recognition." arXiv preprint arXiv:1409.1556 (2014).

Popular Conv Net: ResNet



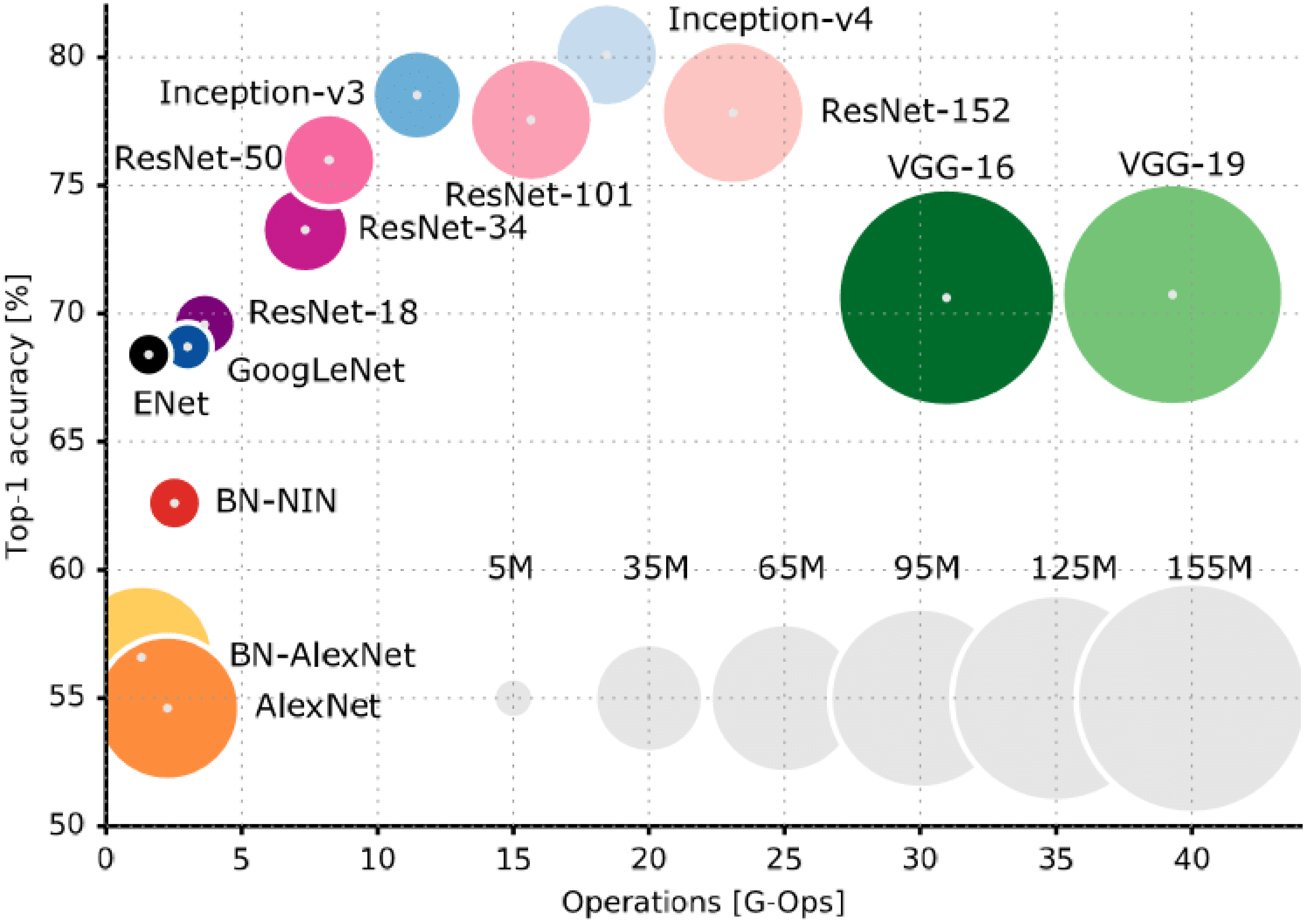
He, Kaiming, et al. "Deep residual learning for image recognition." Proceedings of the IEEE conference on computer vision and pattern recognition. 2016.

Popular Conv Net: Inception Net



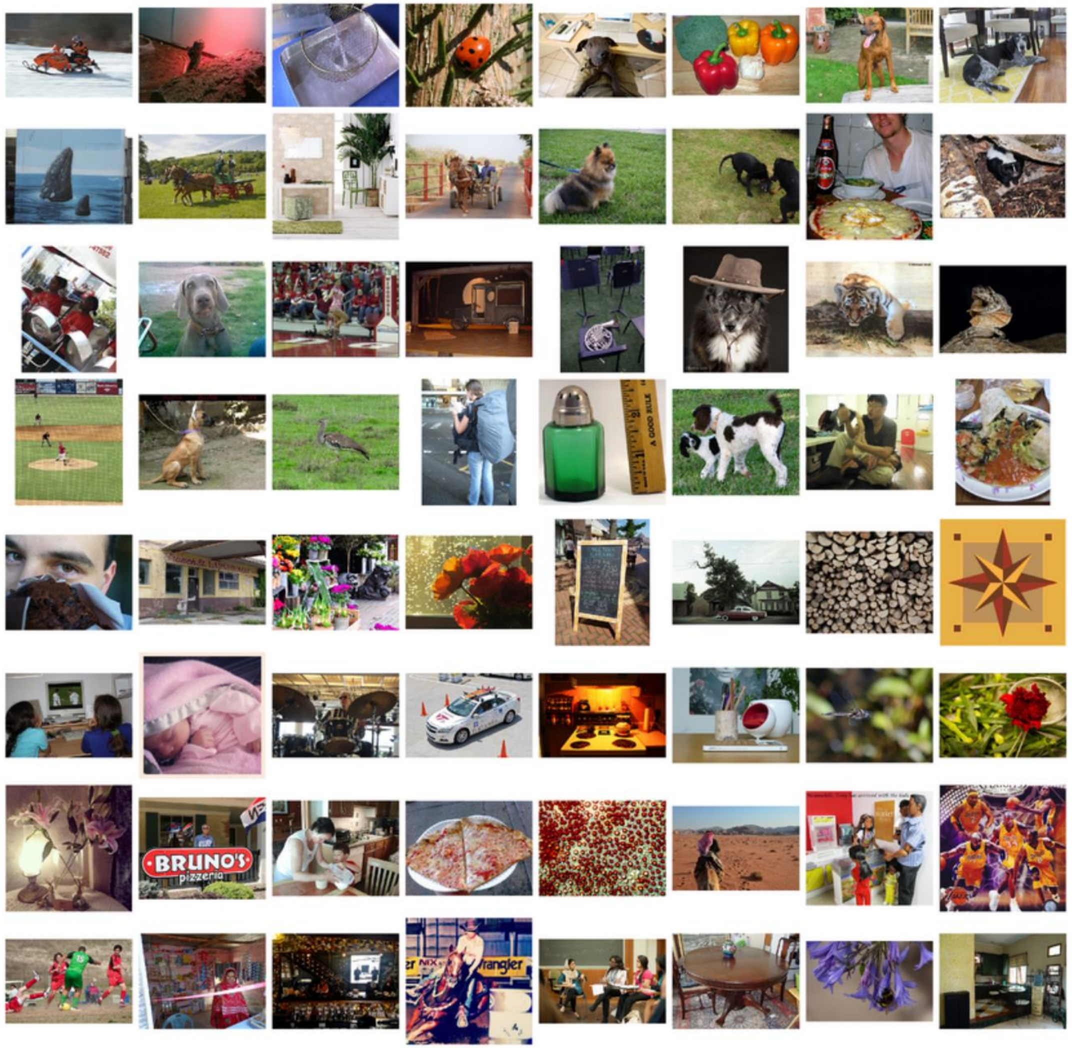
Szegedy, Christian, et al. "Going deeper with convolutions." Proceedings of the IEEE conference on computer vision and pattern recognition. 2015.

Comparison of Networks on ImageNet Classification



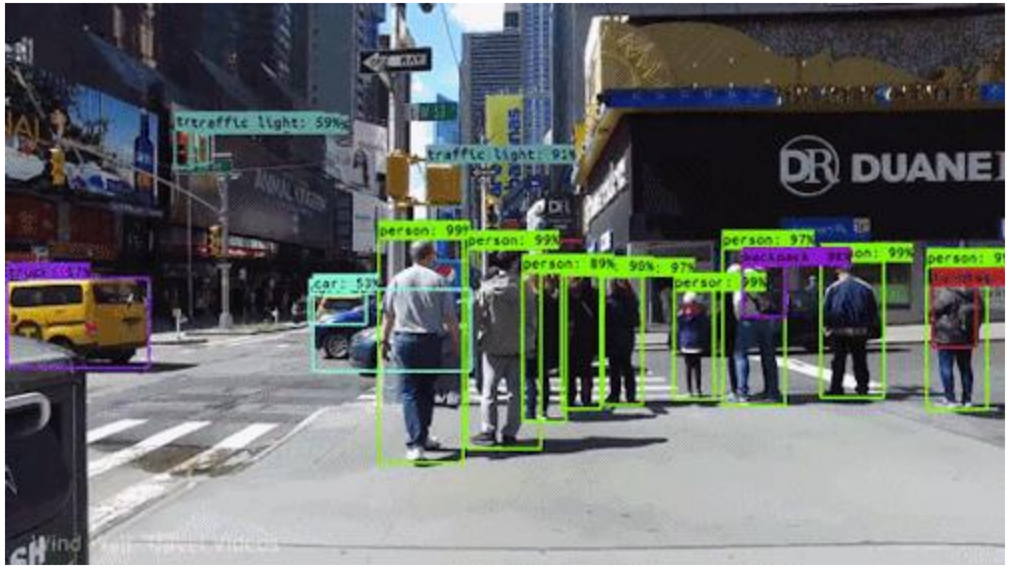
Computer Vision Tasks: Image Classification

- ImageNet is a popular dataset
- 1.2 million training images
- 100 thousand testing images
- 1000 classes



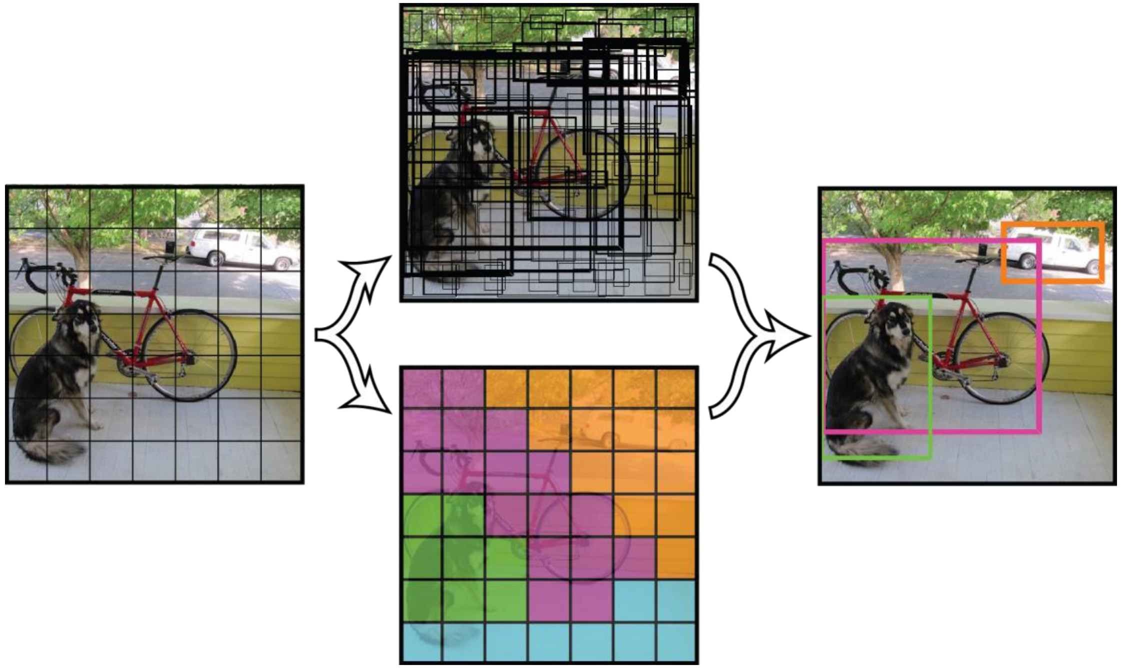
Computer Vision Tasks: Object Detection

- Detect one or multiple object bounding boxes in an image
- Typically multi-tasked with image classification



Object Detection Methods: YOLO (You Only Look Once)

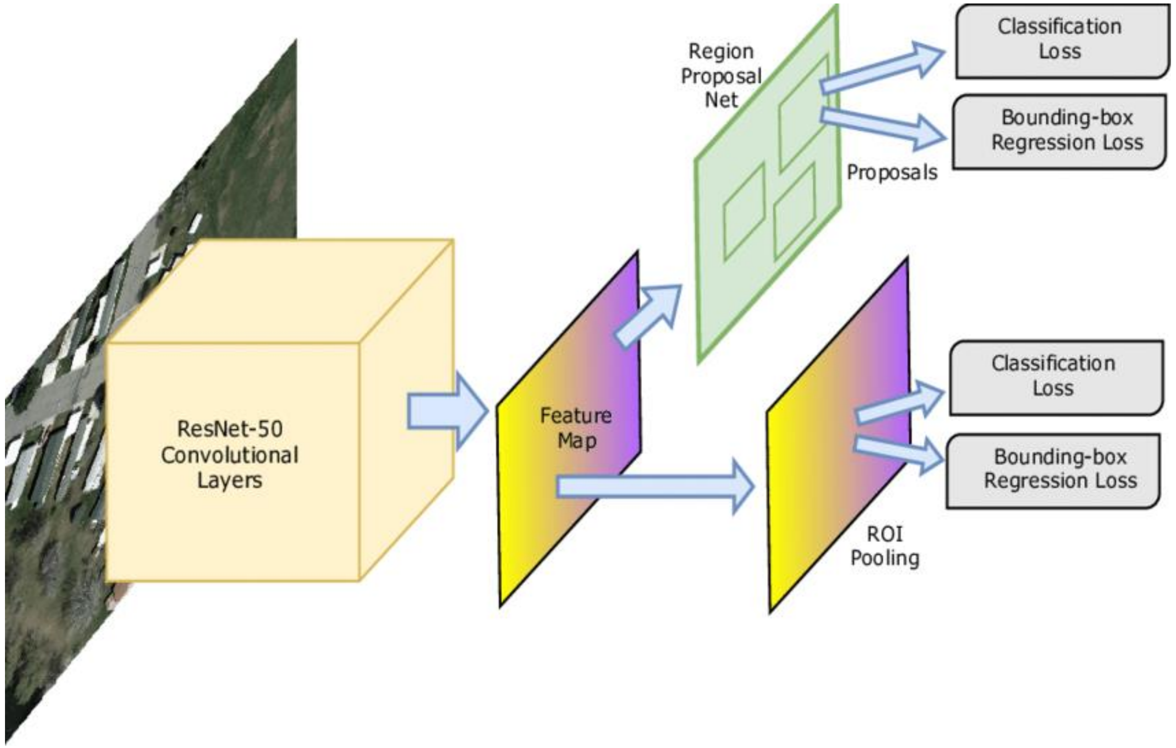
- Single-stage detector



Redmon, Joseph, and Ali Farhadi. "YOLO9000: better, faster, stronger." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.

Object Detection Methods: Faster R-CNN

- Multi-stage detector



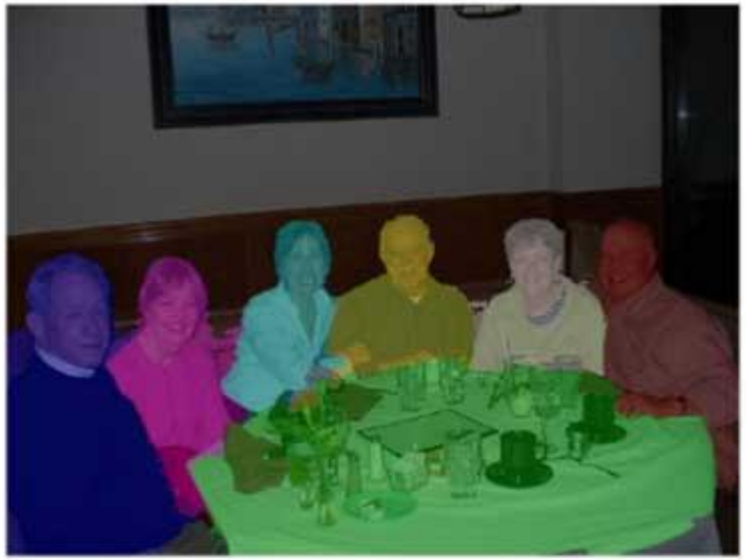
Ren, Shaoqing, et al. "Faster r-cnn: Towards real-time object detection with region proposal networks." Advances in neural information processing systems. 2015.

Computer Vision Tasks: Segmentation

Computer Vision Tasks: Segmentation

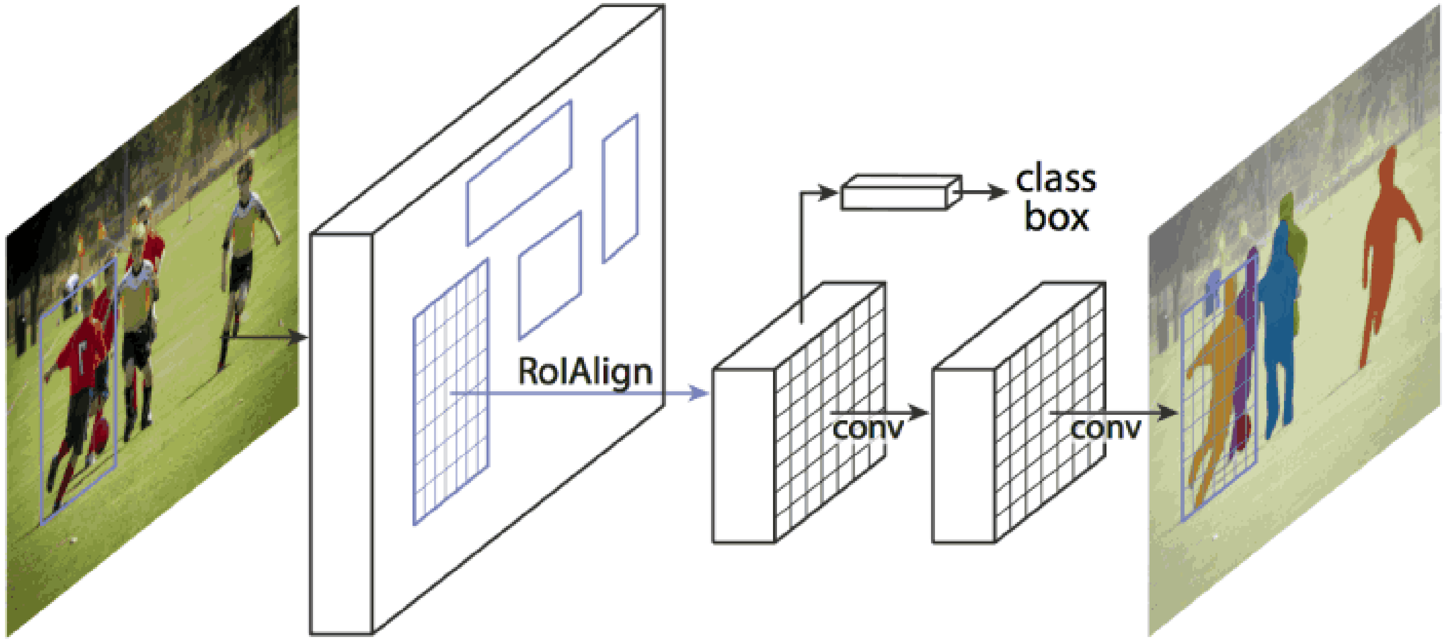
- **Semantic Segmentation:** Detects each pixel and overall object category
- **Instance Segmentation:** Detects each pixel and identifies individual instances of the object

Semantic Segmentation



Instance Segmentation

Instance Segmentation Methods: Mask R-CNN

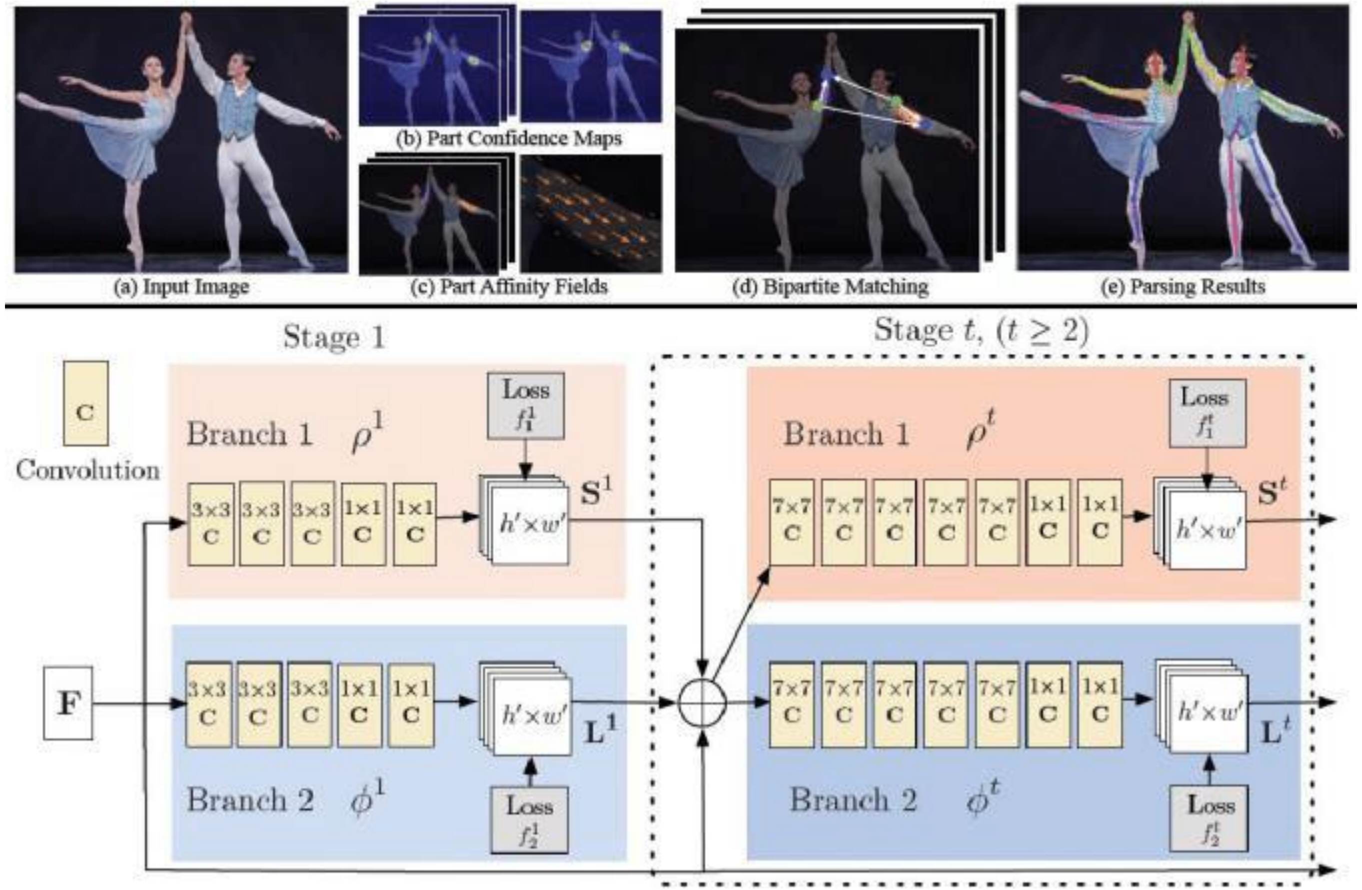


The Mask R-CNN framework for instance segmentation

He, Kaiming, et al. "Mask r-cnn." Proceedings of the IEEE international conference on computer vision. 2017.

Computer Vision Tasks: Pose Estimation

Pose Estimation Methods: OpenPose



Cao, Zhe, et al. "OpenPose: realtime multi-person 2D pose estimation using Part Affinity Fields." arXiv preprint arXiv:1812.08008 (2018).

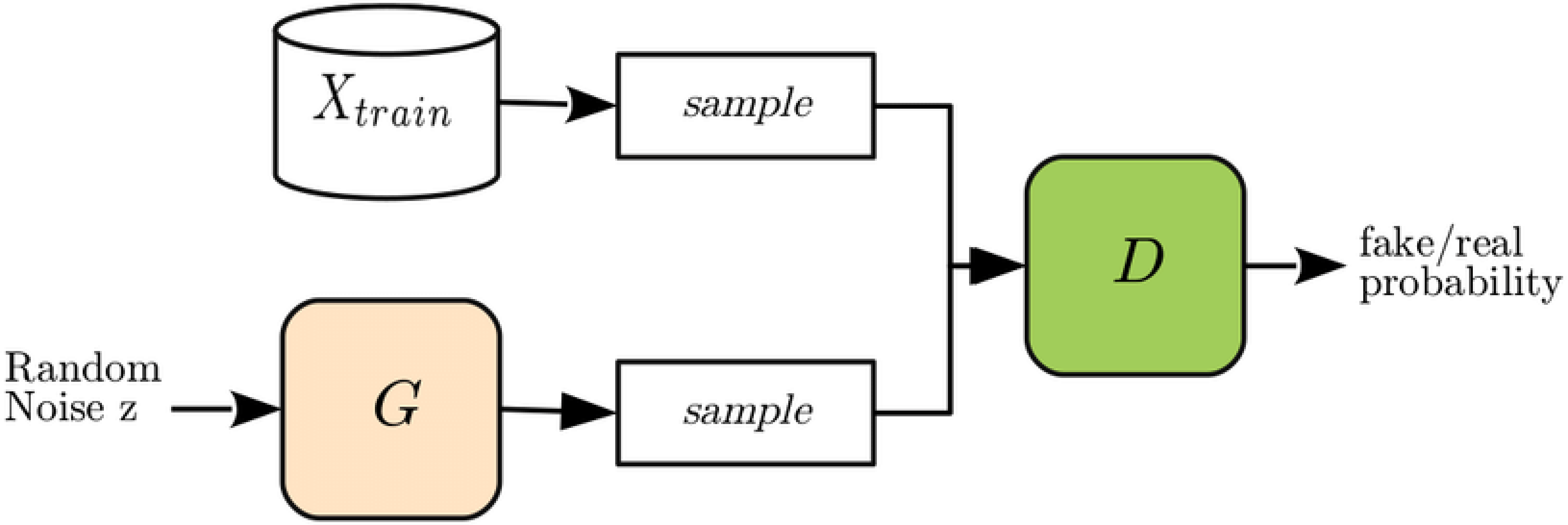
Computer Vision Tasks: Style Transfer

1: Gatys, Leon A., Alexander S. Ecker, and Matthias Bethge. "A neural algorithm of artistic style." arXiv preprint arXiv:1508.06576 (2015).

Computer Vision Tasks: Image Generation

Popular Networks: Generative Adversarial Networks

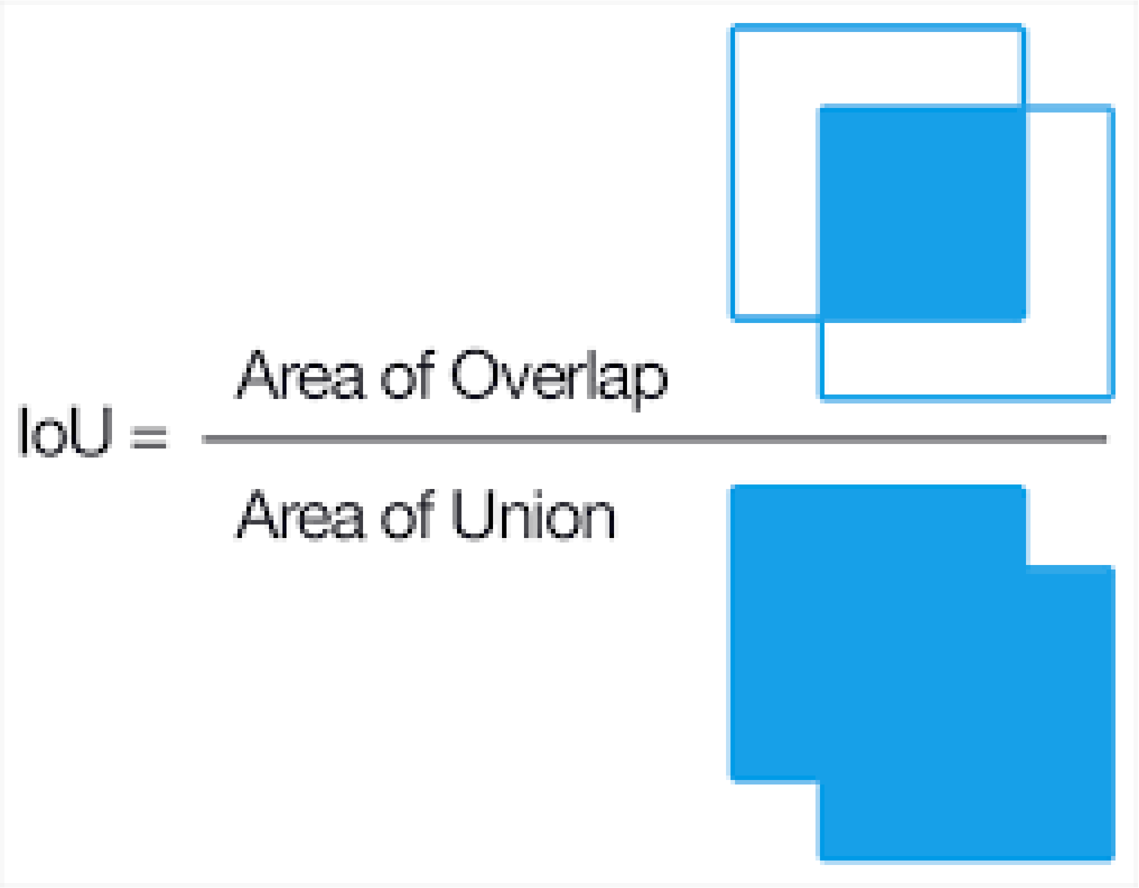
Discriminator tries to distinguish real from fake



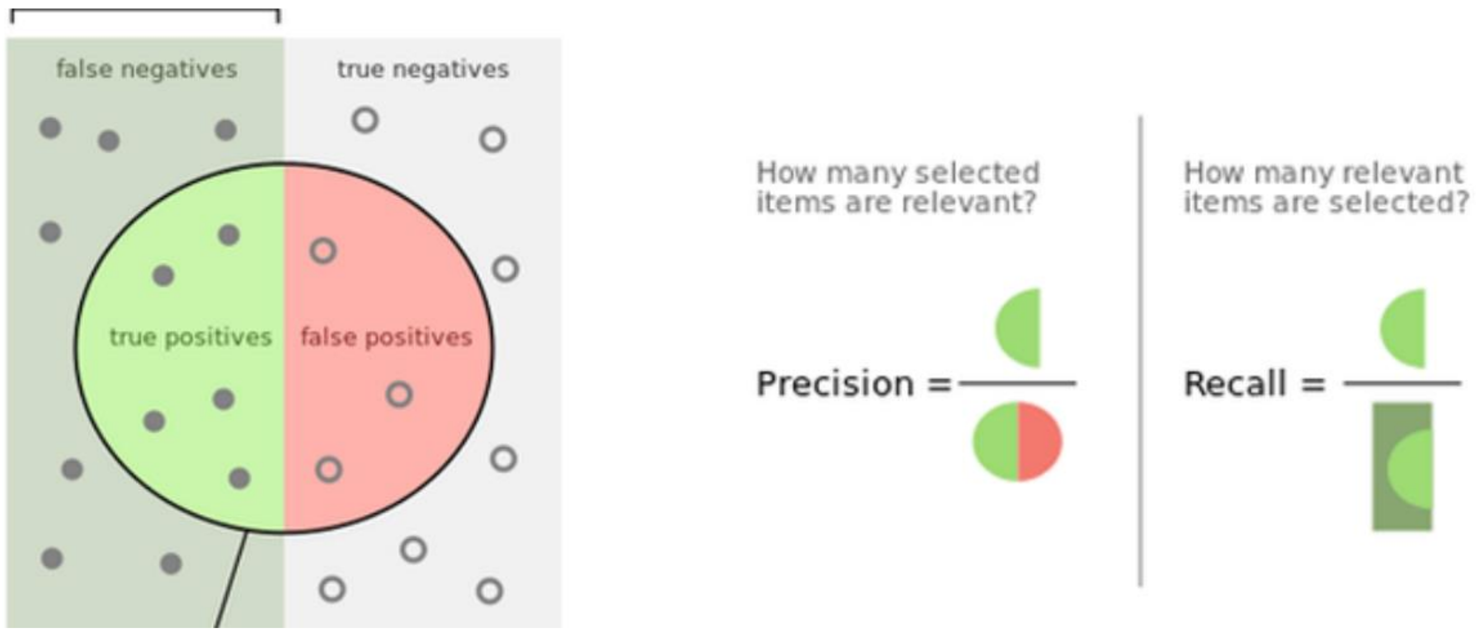
Generator tries to fool the **Discriminator**

1: Goodfellow, Ian, et al. "Generative adversarial nets." Advances in neural information processing systems. 2014.

Evaluation Metrics: Intersection over Union

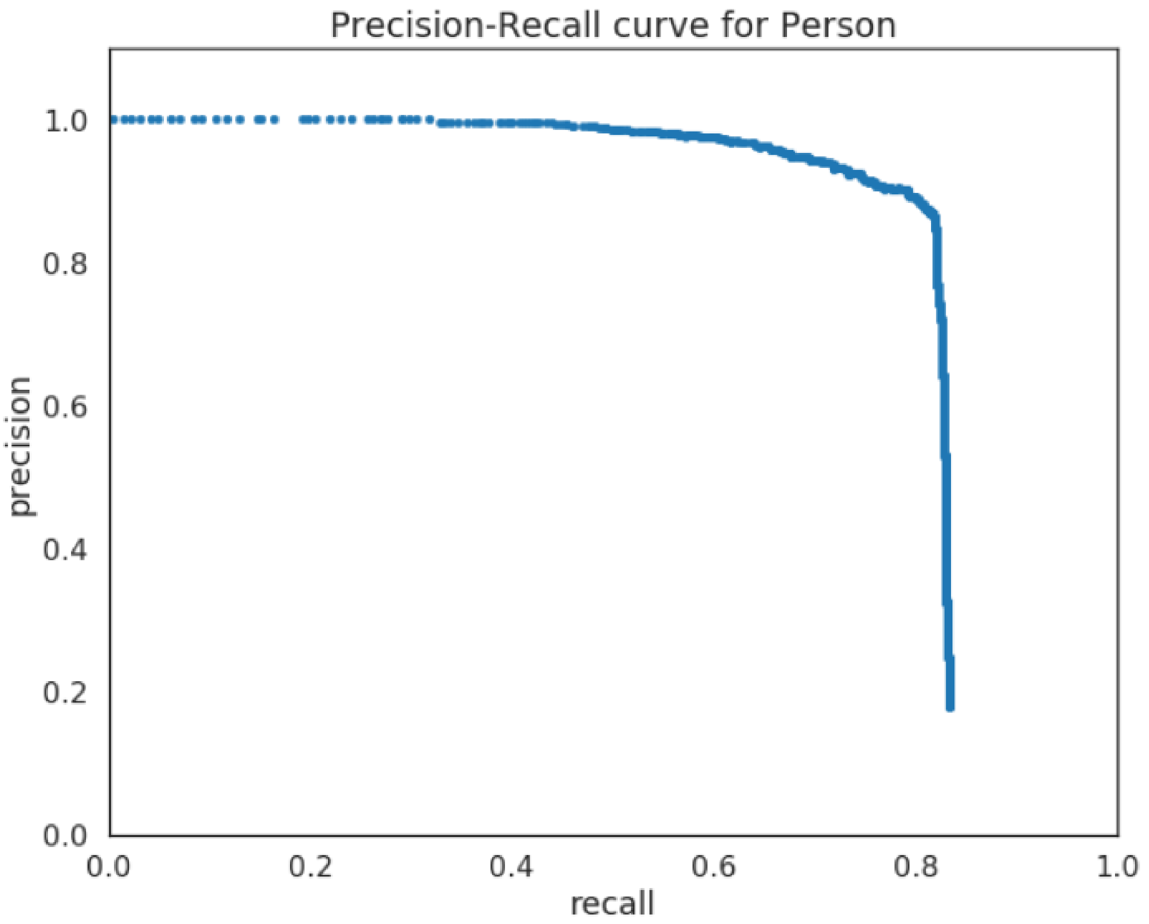


Evaluation Metrics: Precision and Recall



Evaluation Metrics: Precision and Recall

- Plot for varying positive prediction thresholds



Evaluation Metrics: F1 Score

- Single metric considering both precision and recall
- Good for single metric evaluation
- Gives equal importance to precision and recall (this may cause issues when you regard precision more over recall or vice versa)

$$F1 = 2\left(\frac{precision\ x\ recall}{precision + recall}\right)$$

Questions?