291K
Deep Learning for Machine Translation
Convolutional Neural Networks

Lei Li

UCSB

10/6/2021

Outline

- Convolution Layer
- Stride and Padding
- Multiple Channel
- ResNet and Residual Connection
  - gradient vanishing
- Diluted Convolution
- Temporal Convolution
- (Batch Normalization)

Convolutional Networks

- Scale up neural networks to process very large images / video / audio sequences
  - Sparse connections
  - Parameter sharing
- Automatically generalize across spatial translations of inputs
- Applicable to any input that is laid out on a grid (1-D, 2-D, 3-D, …)

Key Idea

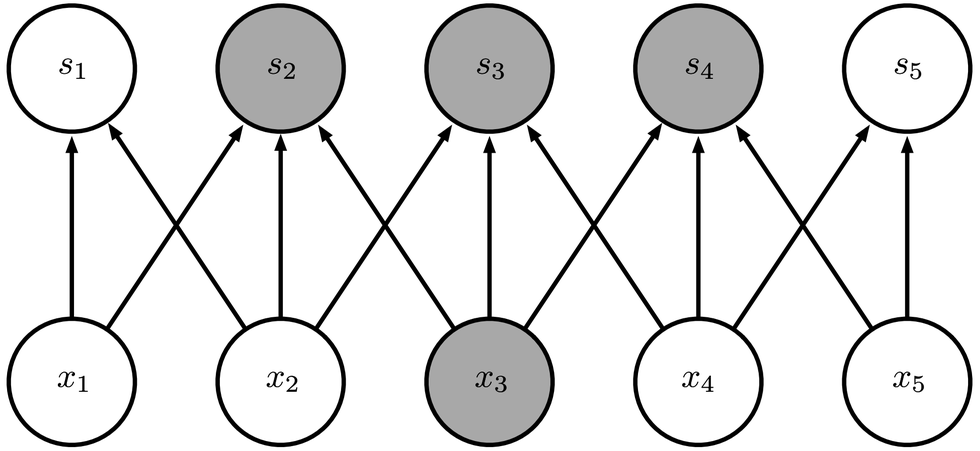
- Replace matrix multiplication in neural nets with convolution
- Everything else stays the same
  - Maximum likelihood
  - Back-propagation
  - etc.

Full Matrix Multiplication

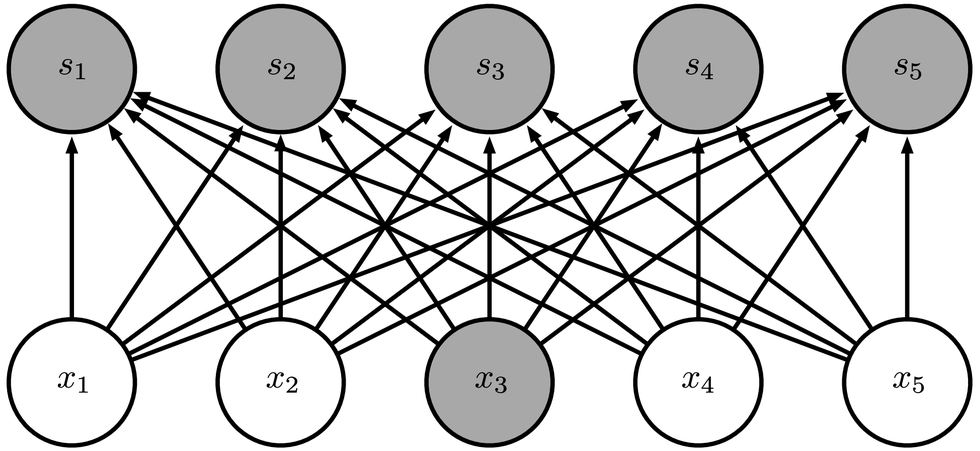
- Consider an image of size m*n, ==> a vector of 1* mn
- In feedforward, linear layer will need a weight matrix mn * p

Sparse Connectivity

Sparse connections due to small convolution kernel

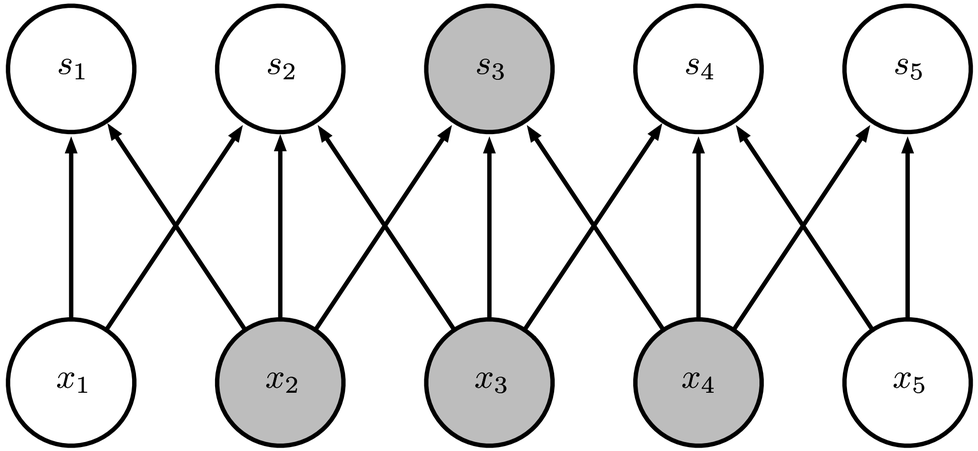


Dense connections

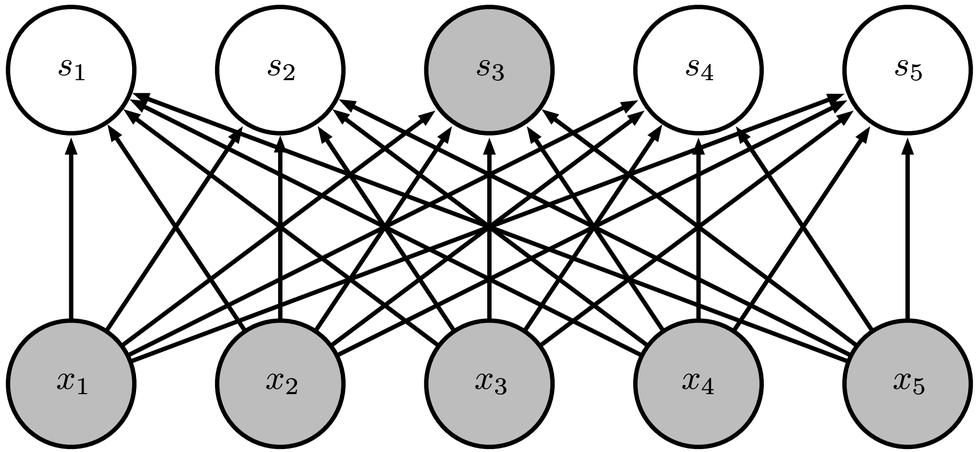


Sparse Connectivity

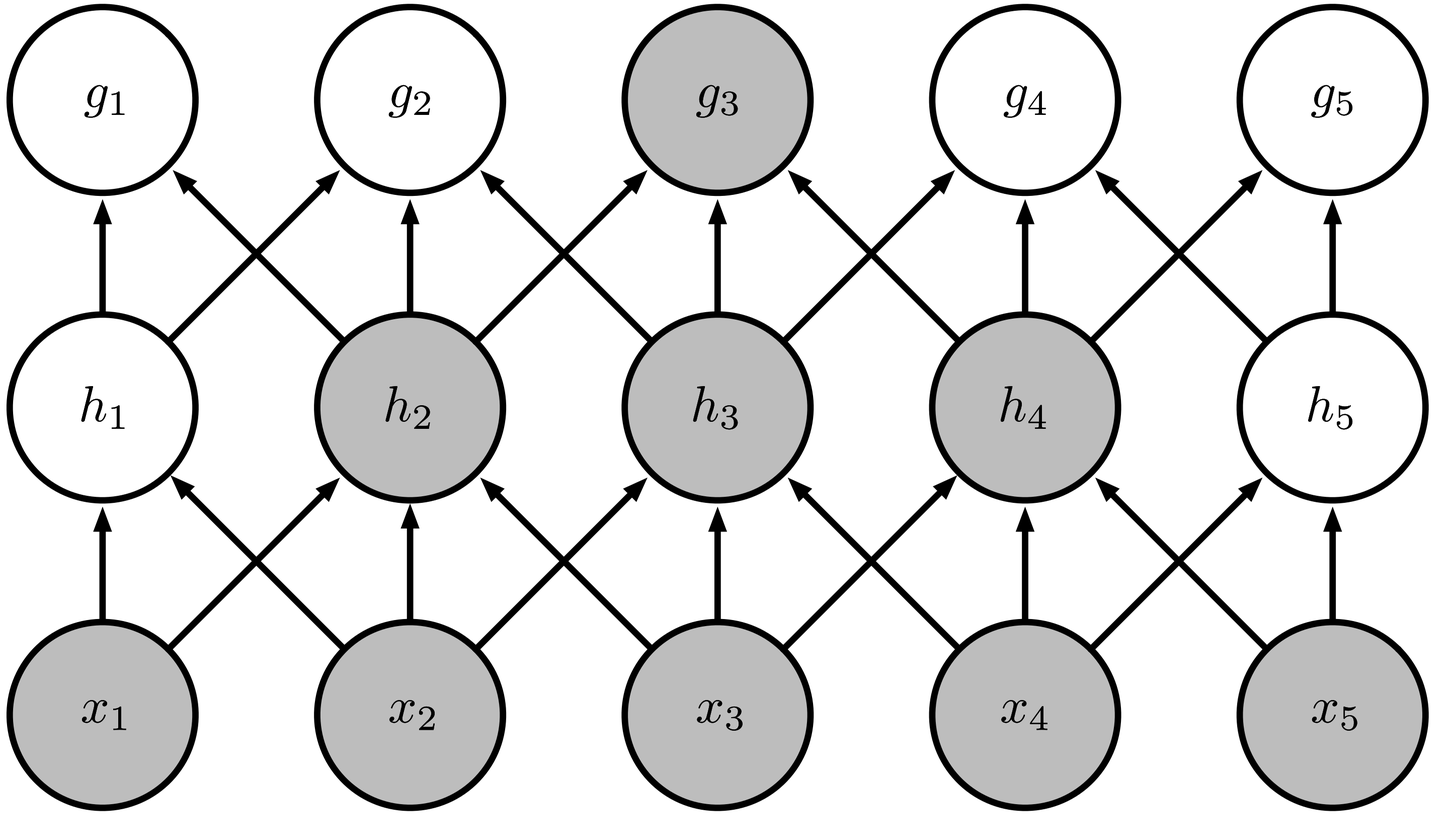
Sparse connections due to small convolution kernel



Dense connections

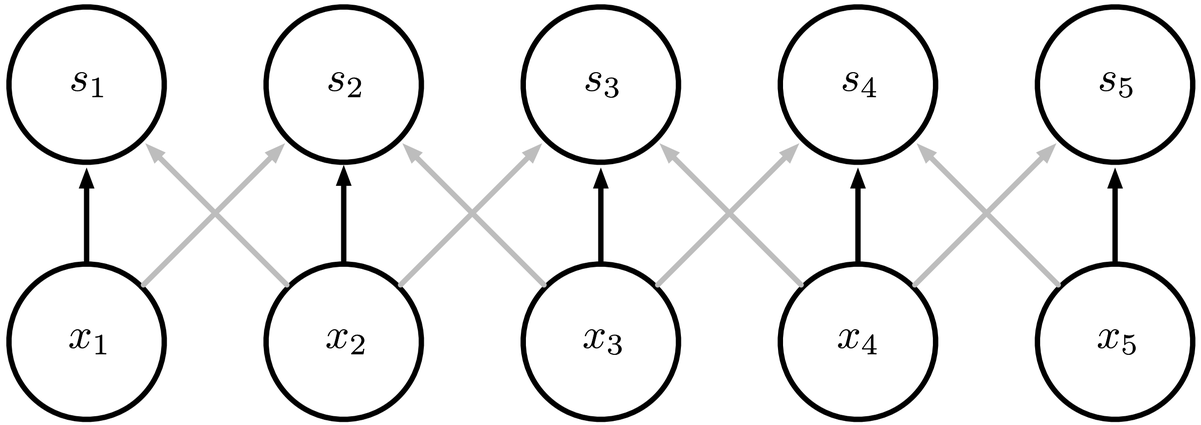


Growing Receptive Fields

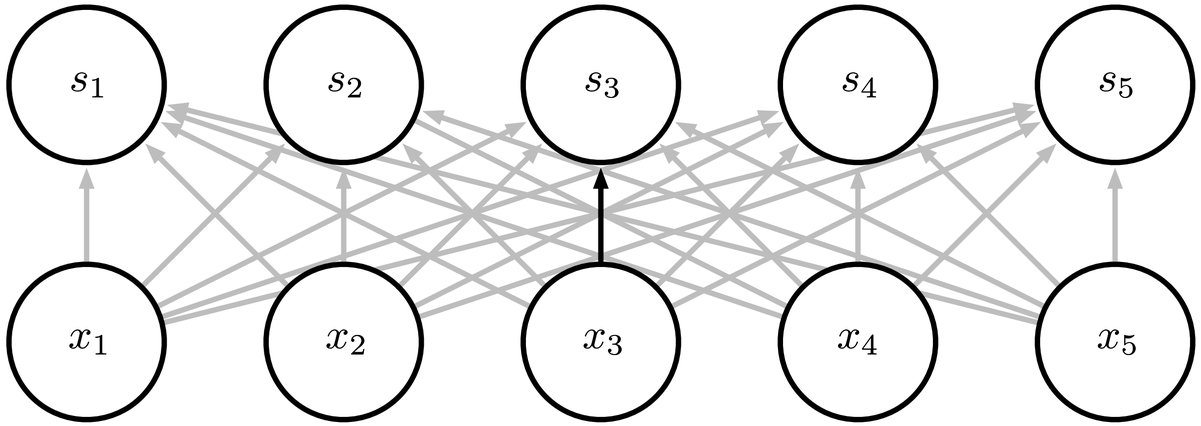


Parameter Sharing

Convolution shares the same parameters across all spatial locations



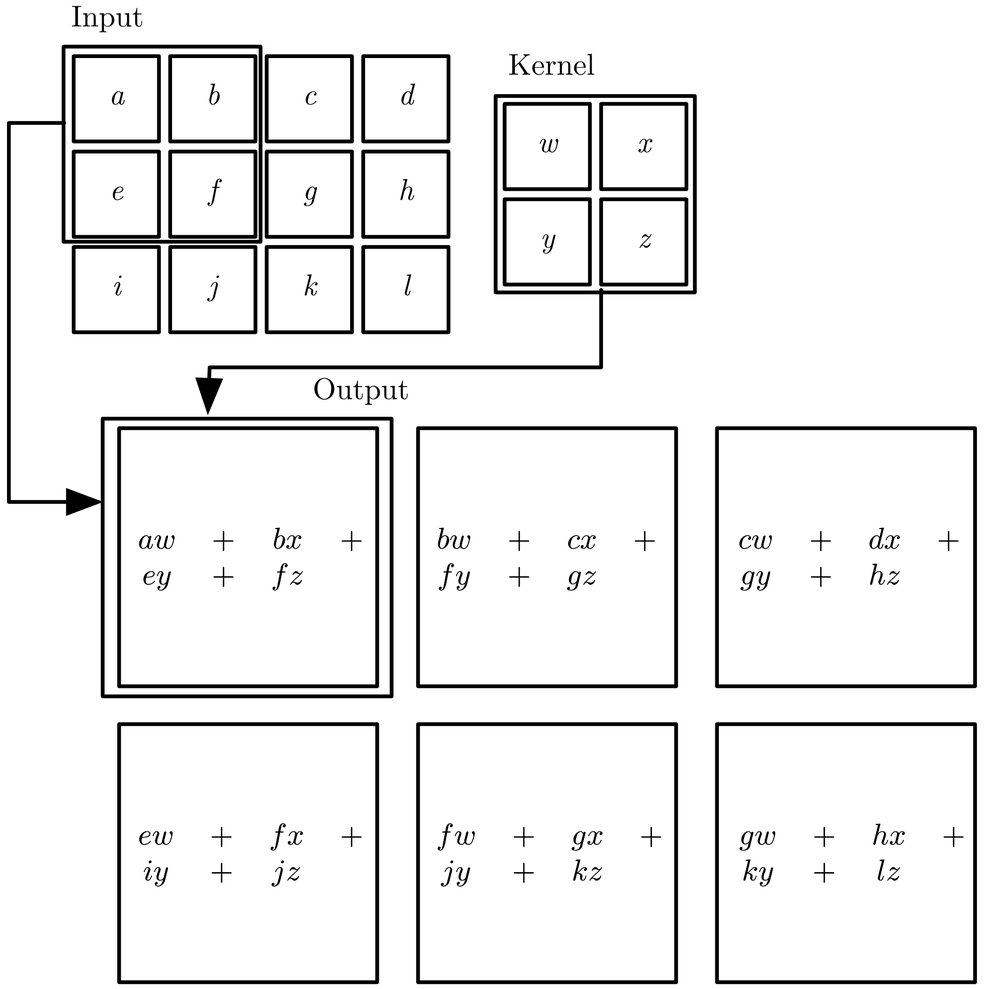
Traditional matrix multiplication does not share any parameters

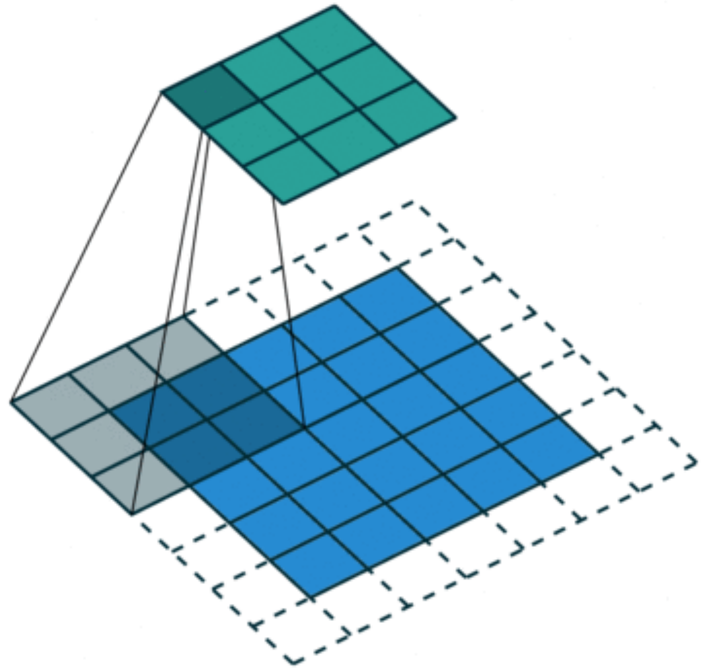


Convolution

- $h(t) = \int f(x) \cdot g(t - x)dx$

2D Convolution



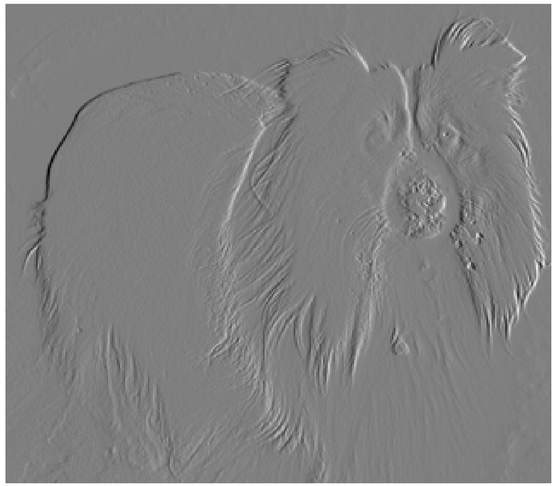


Edge Detection by Convolution

Input

1	-1

Kernel



Output

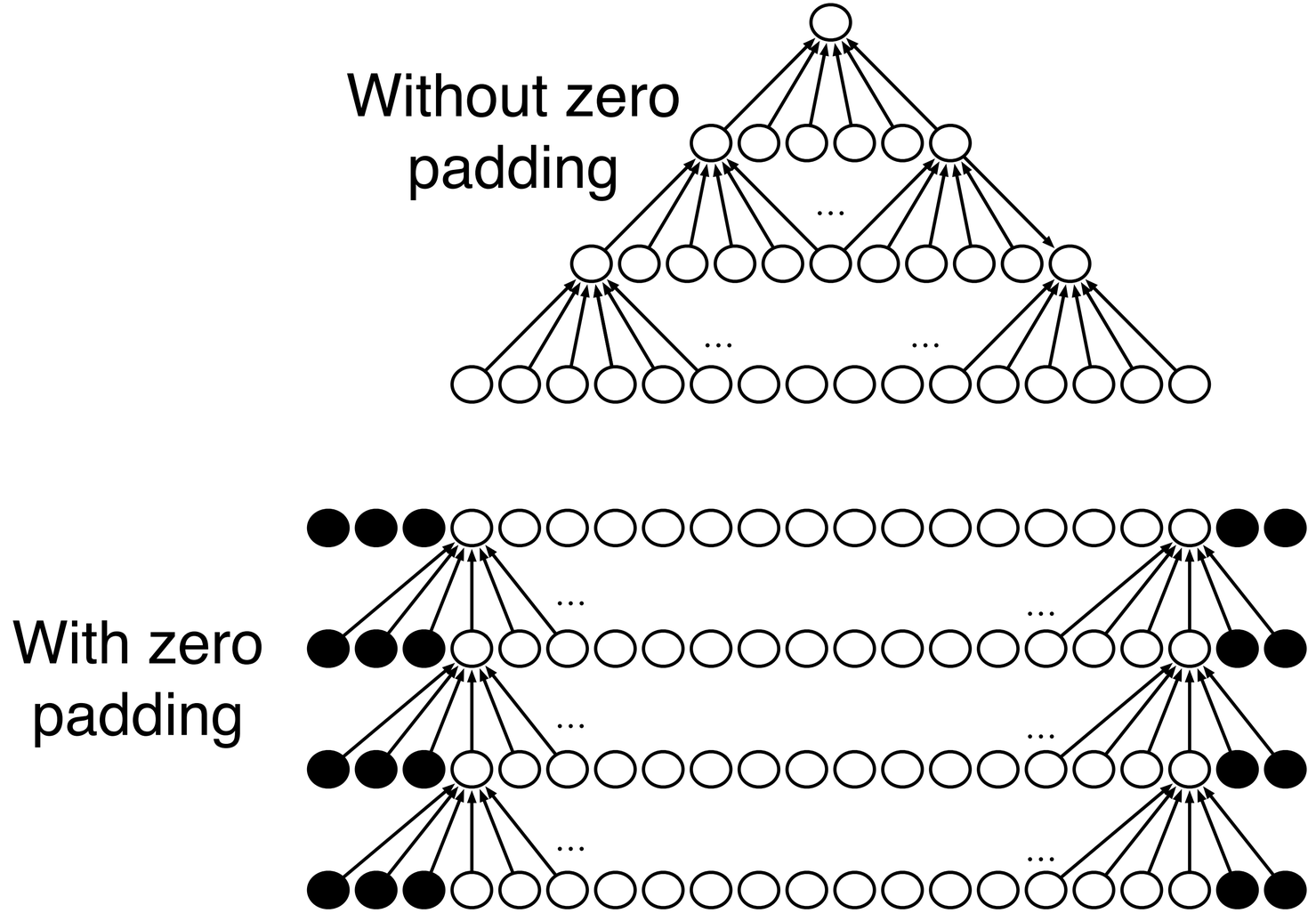
Figure 9.6

Efficiency of Convolution

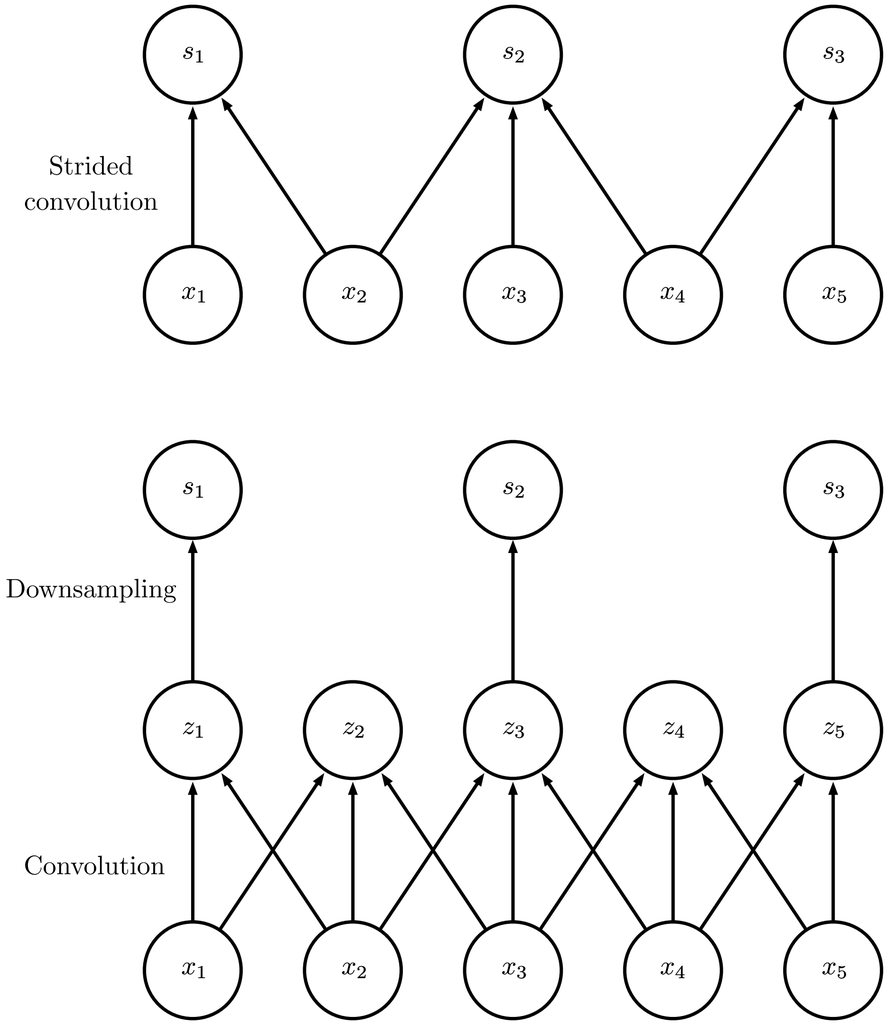
Input size: 320 by 280
Kernel size: 2 by 1
Output size: 319 by 280

	Convolution	Dense matrix	Sparse matrix
Stored floats	2	319*280*320*280 > 8e9	2*319*280 = 178,640
Float muls or adds	319*280*3 = 267,960	> 16e9	Same as convolution (267,960)

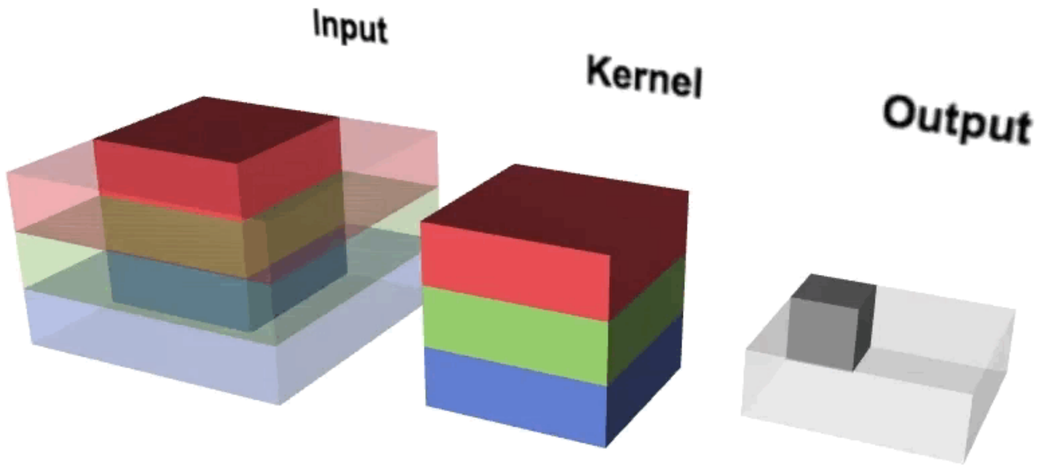
Padding



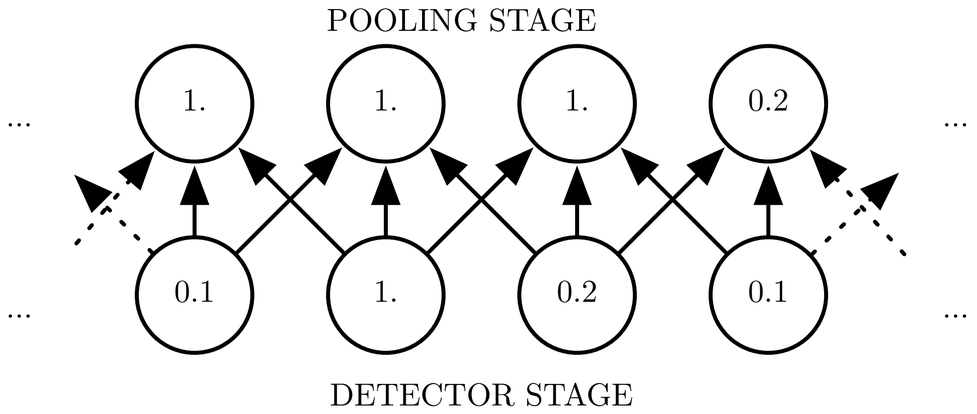
Convolution with Stride

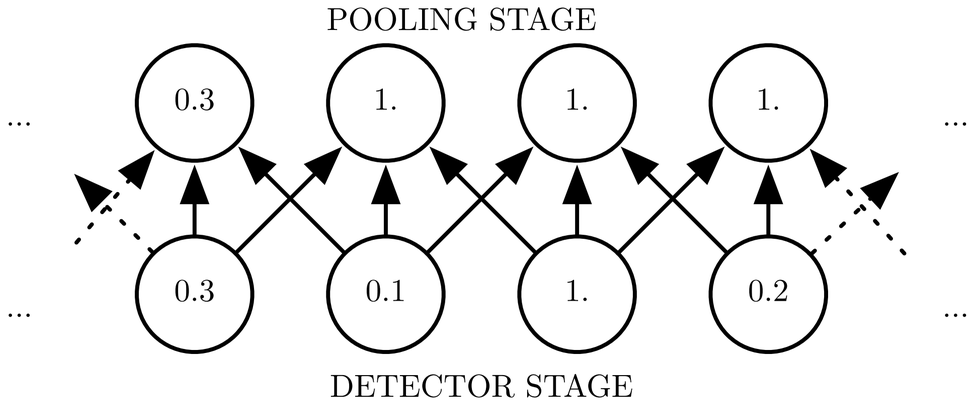


Multi-channel Convolution

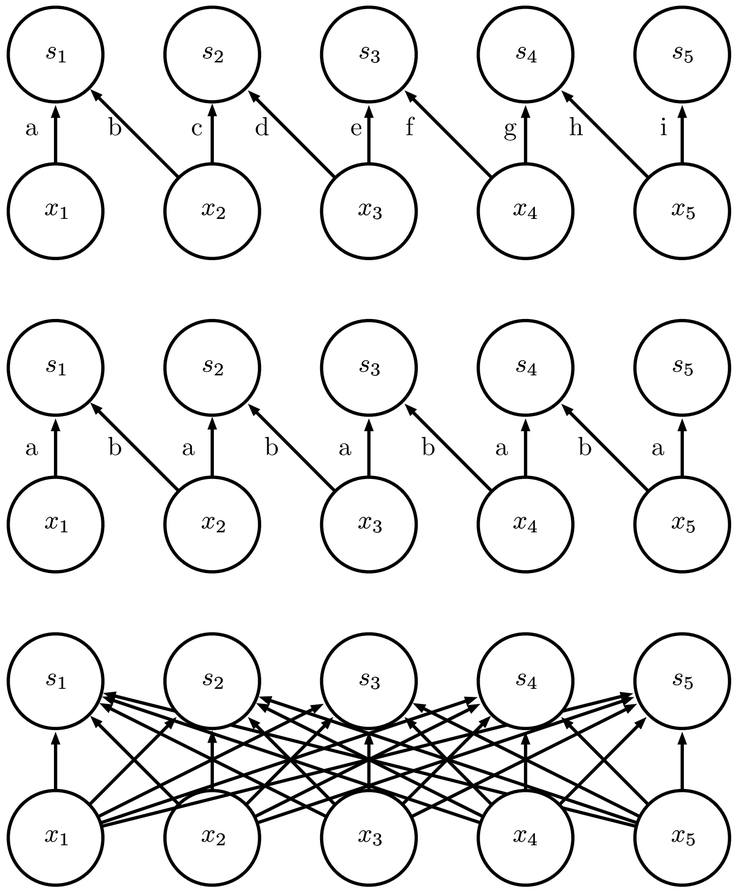


Max Pooling


POOLING STAGE
...
1.
1.
1.
0.2
...
0.1
1.
0.2
0.1
...
DETECTOR STAGE


POOLING STAGE
...
0.3
1.
1.
1.
...
0.3
0.1
1.
0.2
...
DETECTOR STAGE

Kinds of Connectivity



Local connection: like convolution, but no sharing

Convolution

Fully connected

Tiled convolution

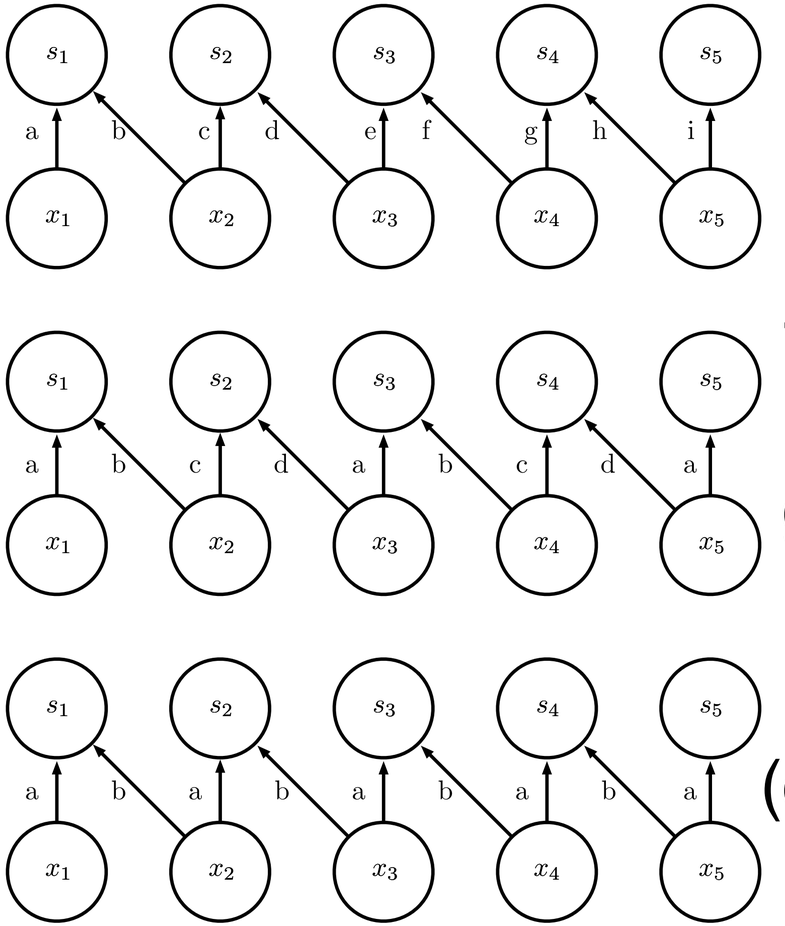


Figure 9.16

Convolutional Network Components

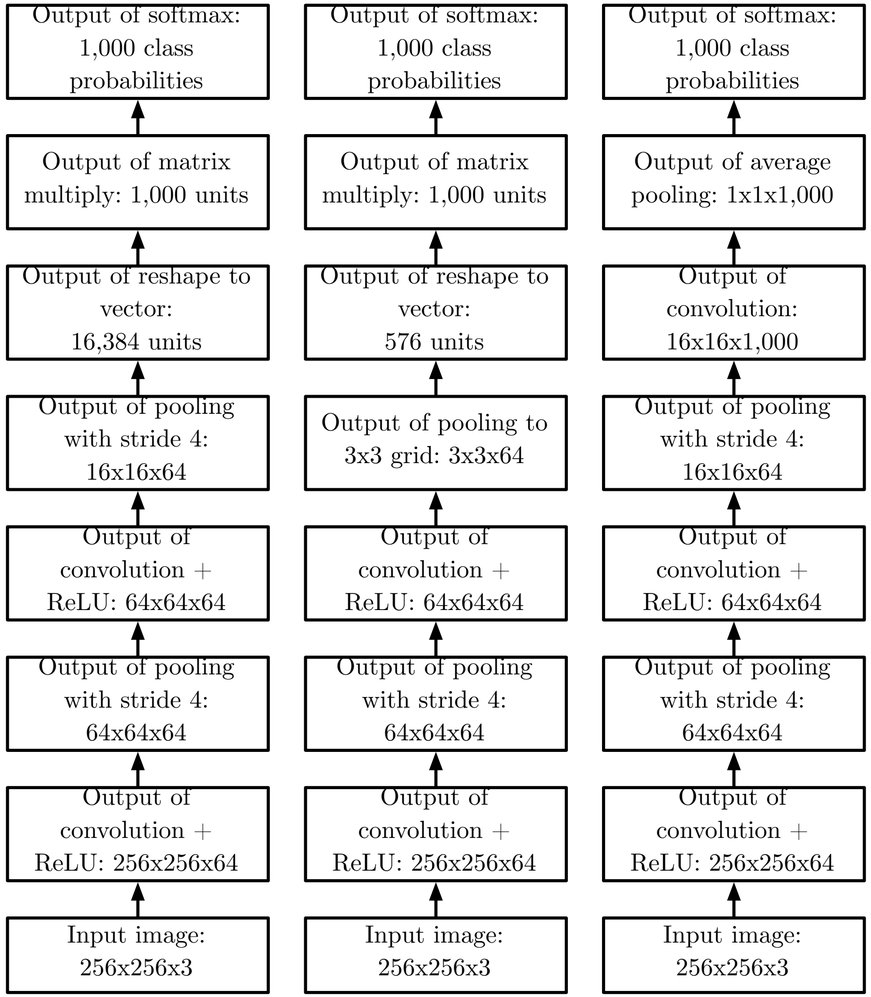
- Conv Layer = Conv -> Relu -> Pooling

Gradient Vanishing

Residual Connection

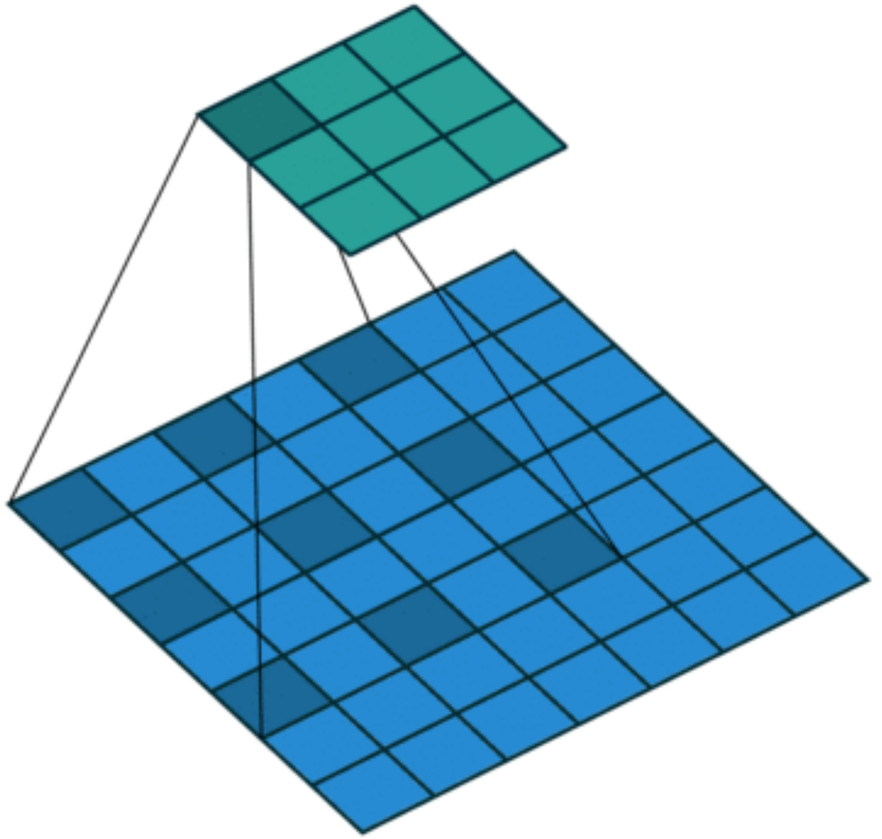
- f represents one layer, f(x) + x
-

Example Classification Architectures



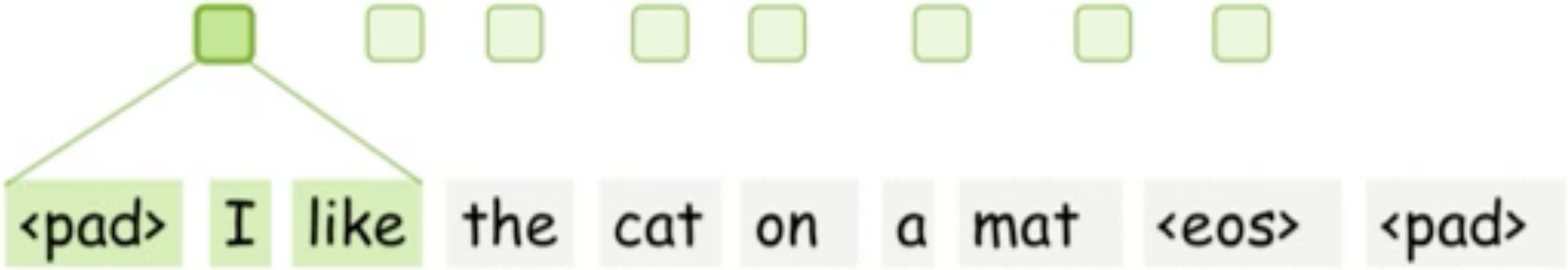
Dilated Convolution

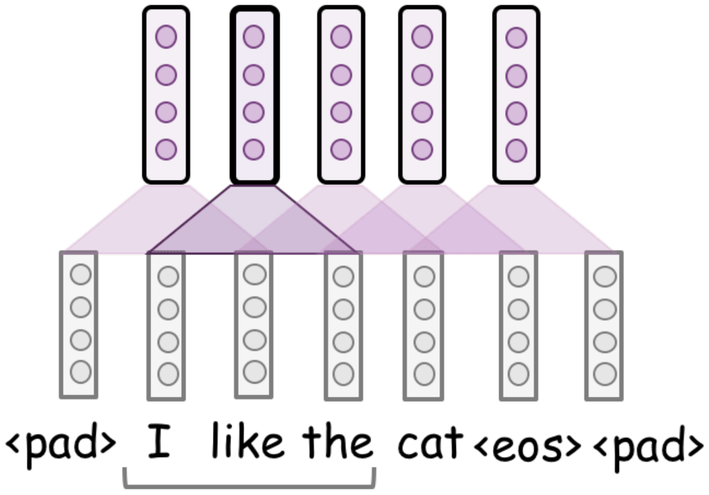
- to enlarge reception field without introducing more parameters

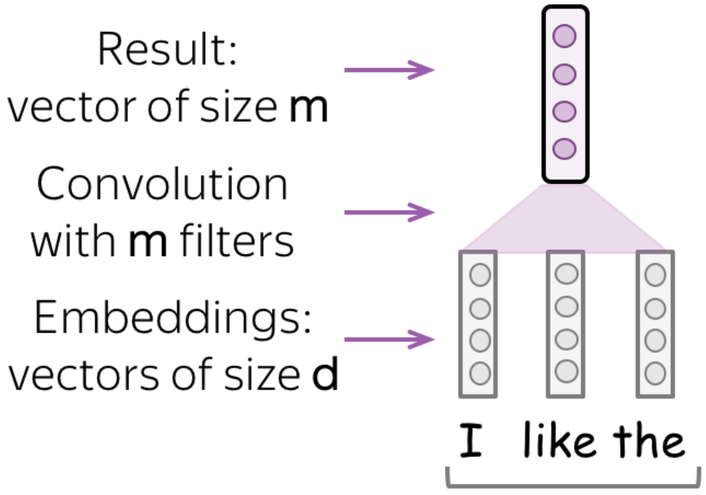


1D CNN for Sequential Data

- Convolution kernel only moves along one direction.

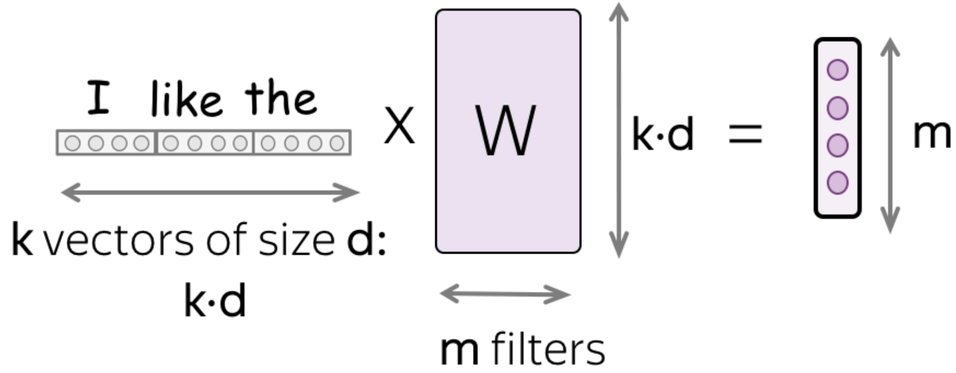




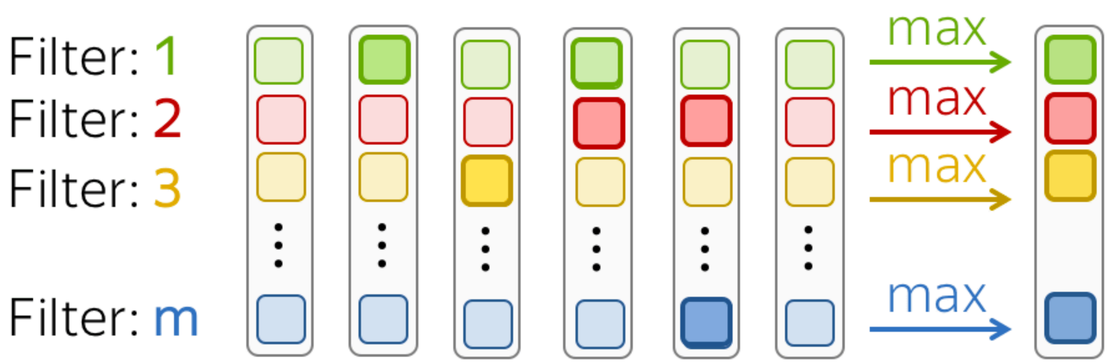


Kernel size k (k=3)
(convolution window size)

Convolution is a linear layer
mapping from k·d to m

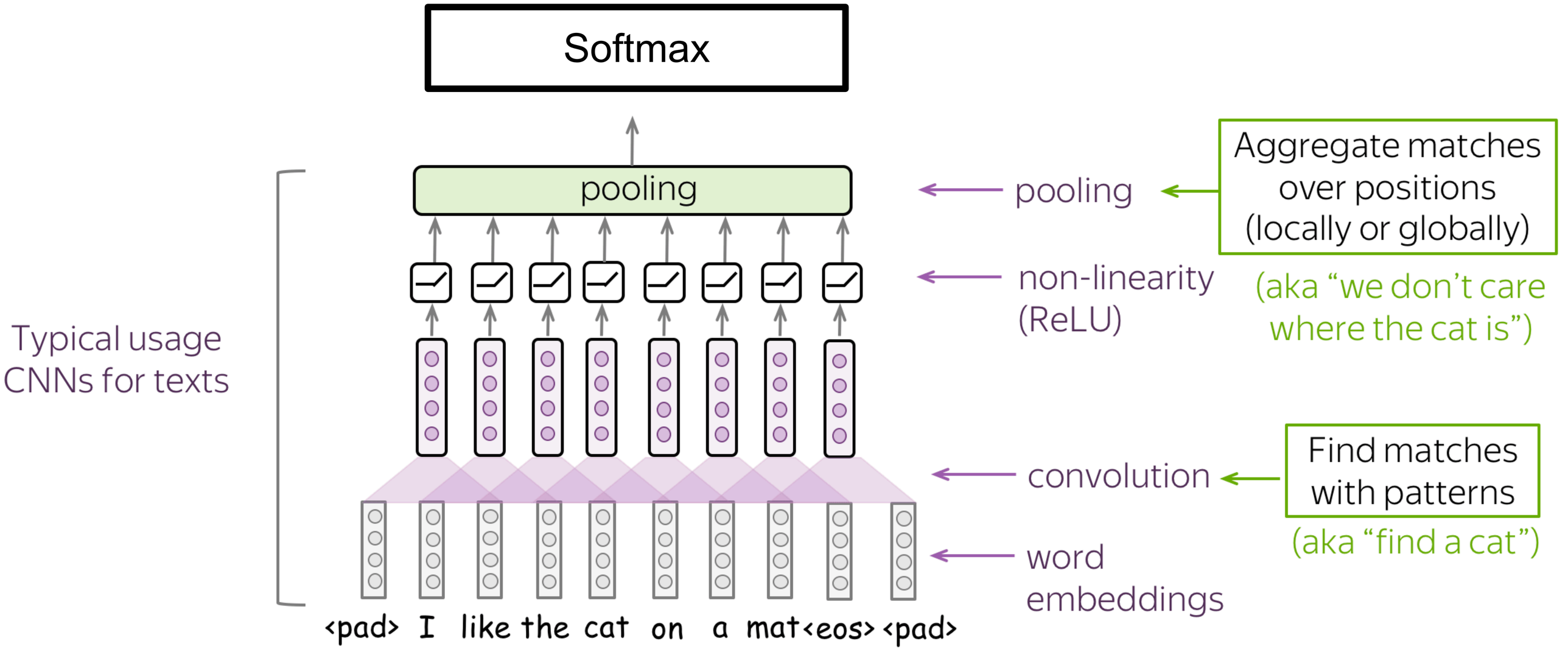


Pooling



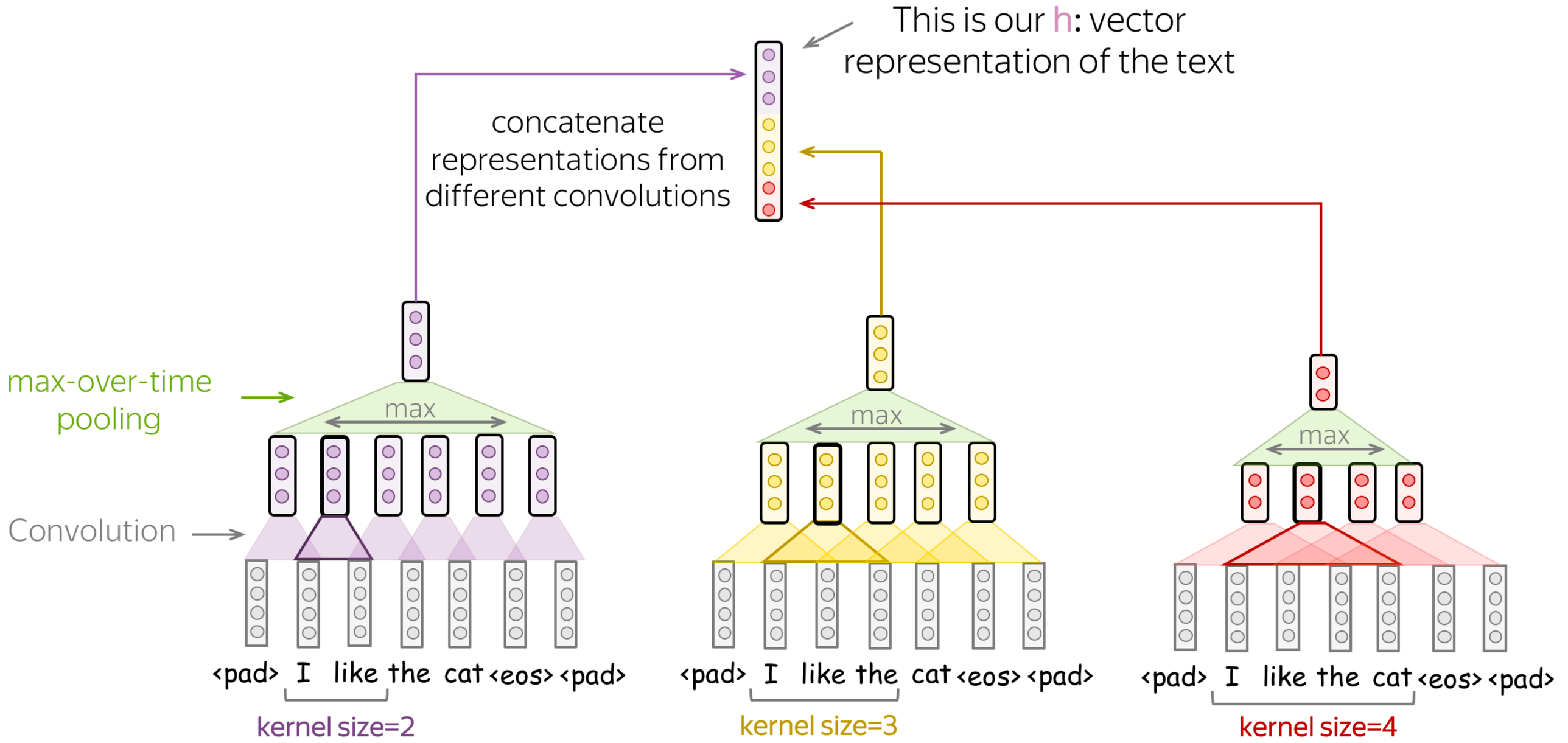
Max pooling: maximum for each dimension (feature)

Text Classification using CNN

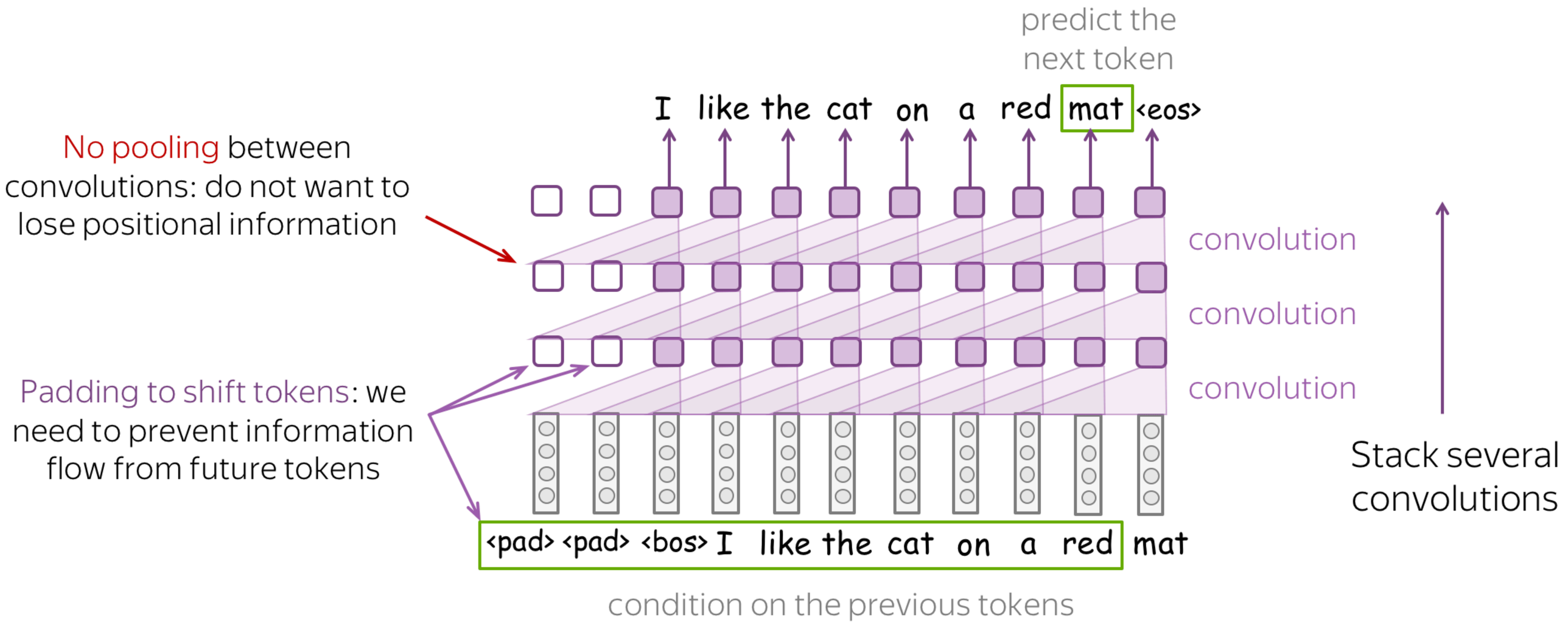


https://lena-voita.github.io/nlp_course/models/convolutional.html

Combining Convolutions w/ Different Kernel Sizes



CNN for Language Modelling



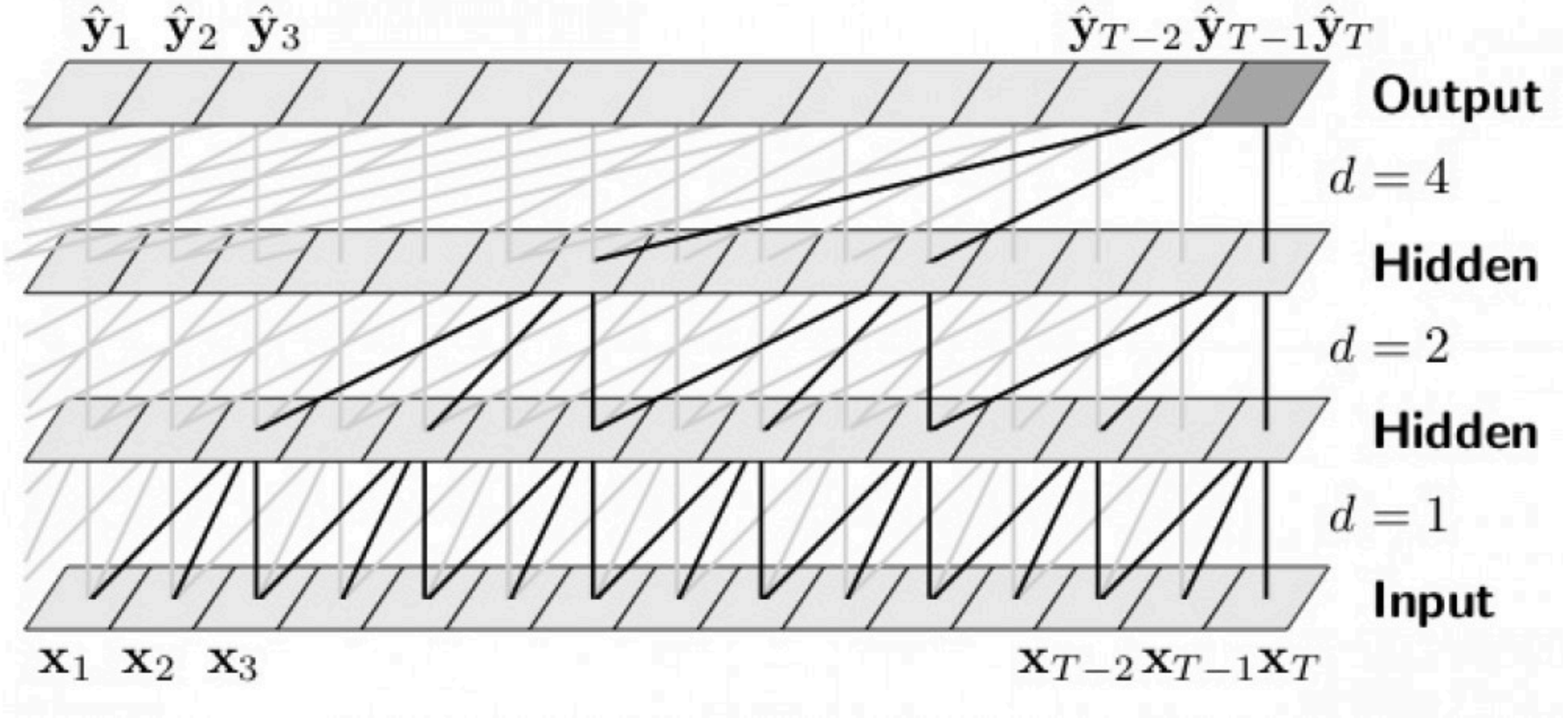
https://lena-voita.github.io/nlp_course/models/convolutional.html

Example n-gram to activate CNN

no matter how are afraid how question is how remaining are how to say how	as little as of more than as high as as much as as low as	a merc spokesman a company spokesman a boeing spokesman a fidelity spokesman a quotron spokeswoman	amr chairman robert chief economist john chicago investor william exchange chairman john texas billionaire robert
would allow the does allow the still expect ford warrant allows the funds allow investors	more evident among a dispute among bargain-hunting among growing fear among paintings listed among	facilities will substantially which would substantially dean witter actually we 'll probably you should really	have until nov. operation since aug. quarter ended sept. terrible tuesday oct. even before june

Temporal Convolutional Network (TCN)

- 1D convolution + dilated + residual connection



Bai et al, An Empirical Evaluation of Generic Convolutional and Recurrent Networks for Sequence Modeling. 2018

Major Architectures

- All Convolutional Net: no pooling layers, just use strided convolution to shrink representation size
- Inception: complicated architecture designed to achieve high accuracy with low computational cost
- ResNet: blocks of layers with same spatial size, with each layer's output added to the same buffer that is repeatedly updated. Very many updates = very deep net, but without vanishing gradient.

Reference

- Kalchbrenner et al. A Convolutional Neural Network for Modelling Sentences, 2014
- He et al. Deep Residual Learning for Image Recognition, 2016
- Pham et al. Convolutional Neural Network Language Models, 2016