Convolutional Neural Networks for Text Classification

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Outline

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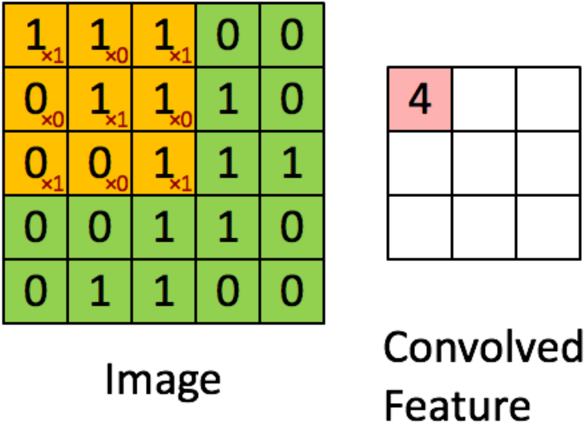
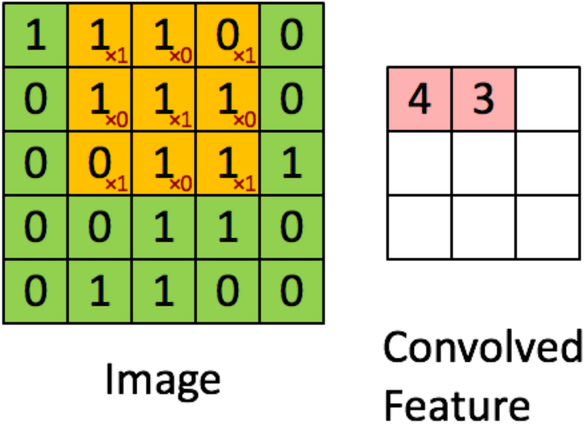
What is a Convolution?

- Convolutions are great for extracting features from Images.
- Convolutional Neural Networks (CNN) are biologically-inspired variants of MLPs



Green: Input, Yellow: Convolutional Filter, Red: Output



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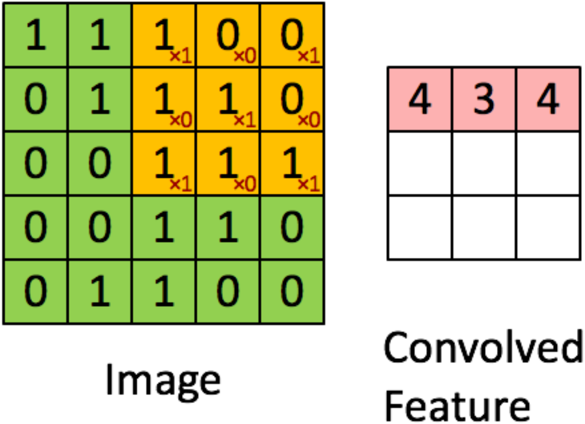

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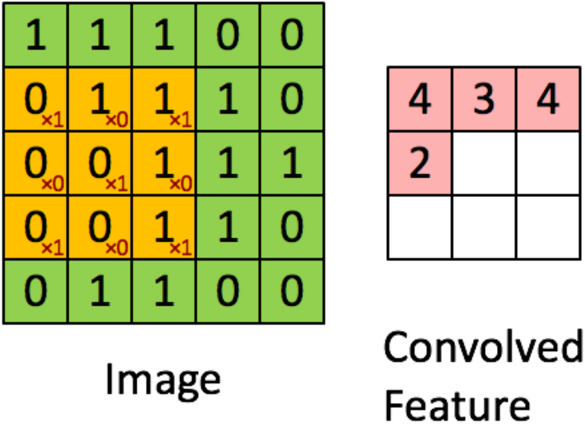

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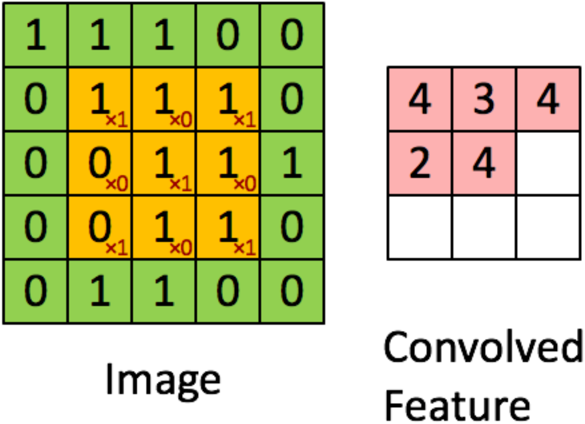

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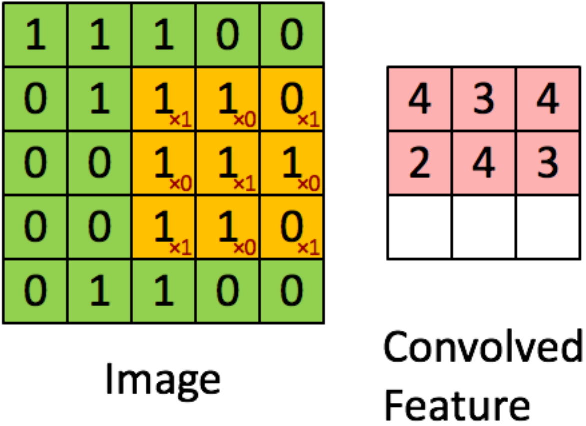

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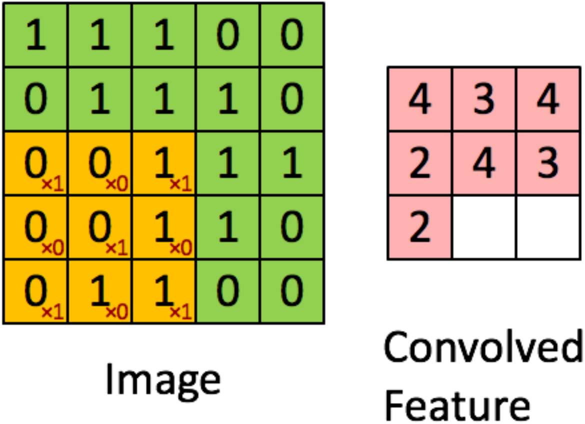

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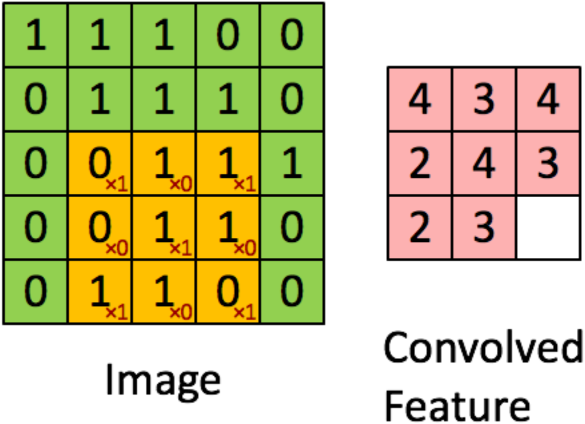

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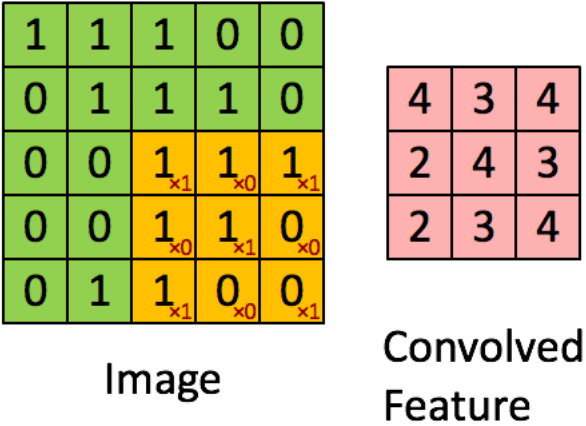

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Convolutional Neural Network

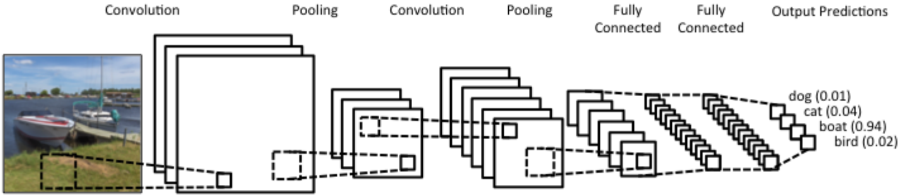


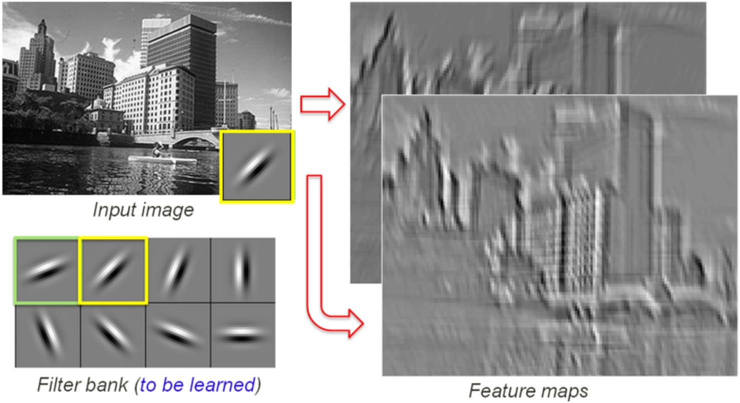
Figure 1: Close up of Convolutional Neural Network

Convolutional Neural Network

- CNNs are networks composed of several layers of convolutions with nonlinear activation functions like ReLU or tanh applied to the results.
- Traditional Layers are fully connected, instead CNN use local connections.
- Each layer applies different filters (thousands) like the ones showed above, and combines their results.

Properties of Convolutional Neural Networks

- Local Invariance
- Compositionality



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CNN in NLP

Do they make sense in NLP?

Perhaps Recurrent Neural Networks would make more sense trying to learn patterns extracted from a text sequence. They are not cognitively or linguistically plausible.

Advantage

There are fast GPU implementations for CNNs

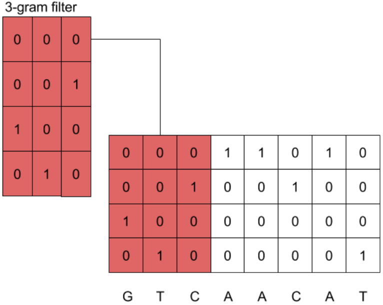
An example of how CNN work

3-gram filter

0	0	0
0	0	1
1	0	0
0	1	0

G	T	C	A	A	C	A	T
0	0	0	1	1	0	1	0
0	0	1	0	0	1	0	0
1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	1

An example of how CNN work



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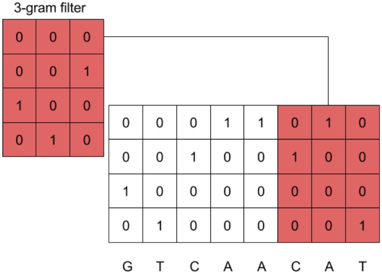

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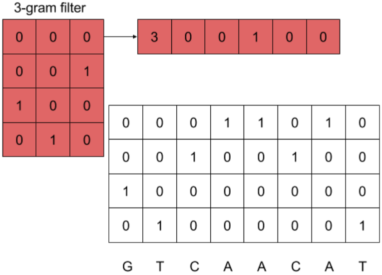

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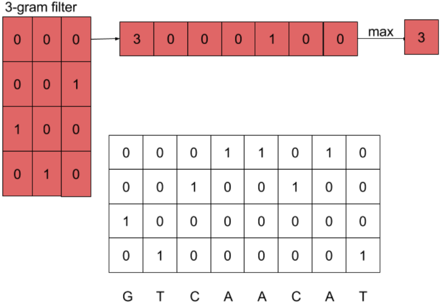

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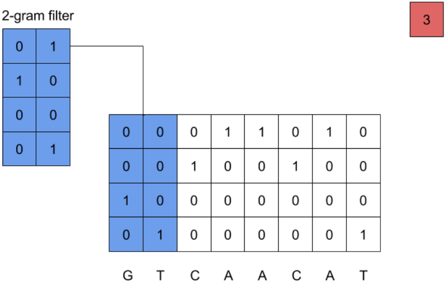

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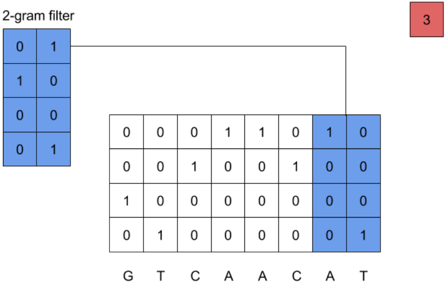

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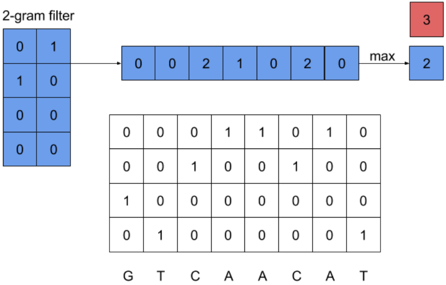

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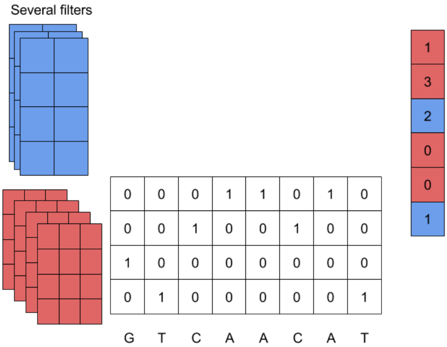

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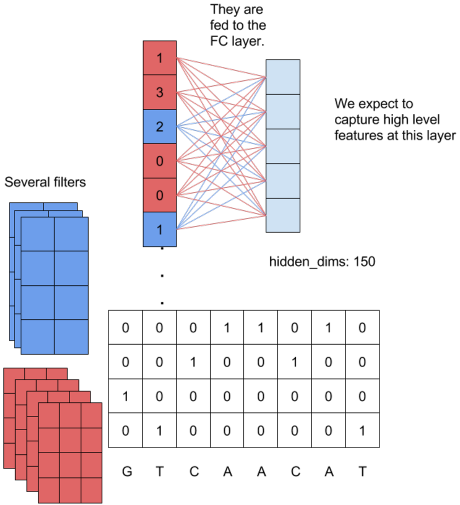

Char-CNN

Let's try this model

Char-CNN

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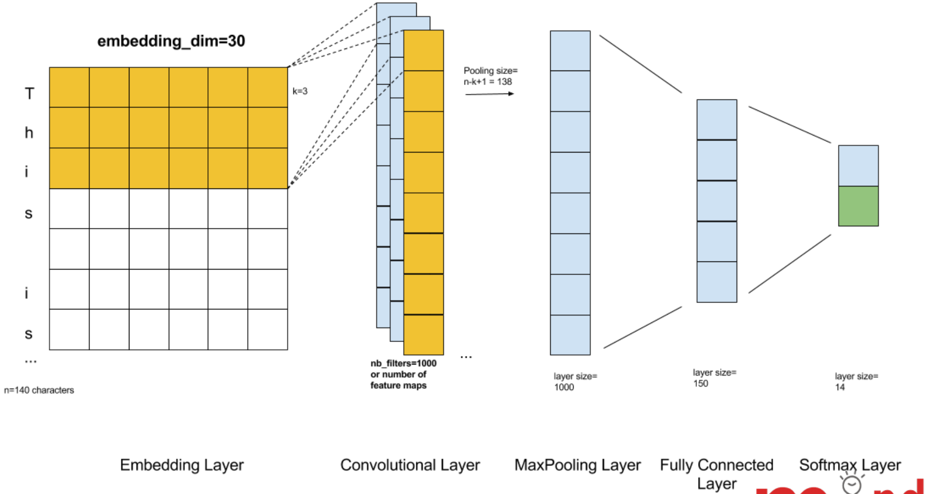
$C \in \mathbb{R}^{d \times l}$: Matrix representation of a sequence of length l(140, 300, ?).

$H \in \mathbb{R}^{d \times w}$: Convolutional filter matrix where,

d : Dimensionality of character embeddings (used 30)

w : Width of convolution filter (3, 4, 5)

A simple architecture



Steps for applying a CNN

1. Apply a convolution between C and H to obtain a vector $f \in \mathbb{R}^{l-w+1}$

$$f[i] = \langle C[*, i : i + w - 1], H \rangle$$

$\langle A, B \rangle$ is the Frobenius inner product. $Tr(AB^T)$

2. This vector f is also known as feature map.
3. Take the maximum value over time as the feature that represents filter H. (K-max pooling)

$$\widehat{f} = relu(\max_i \{f[i]\} + b)$$

4. Then we do the same for all m filters.

$$z = [\widehat{f_i}, ..., \widehat{f_m}]$$

Intution behind

- Why *ReLU* and not *tanh*?
- Should I use multiple filter weights *H*?
- Should I use variable filter widths *w*?
- Can I add another channel as in Computer Vision domain?
- Is Max-Pooling capturing the most important activation?
- Would they capture morphological relations?

Outline

Regularization tricks

- Use dropout (Gradients are only backpropagated through certain inputs of z).
- Constrain L_2 norms of weight vectors of each class(rows in Softmax matrx $W^{(S)}$) to a fixed number: If $\|W_c^{(S)}\| > s$, the rescale it so $\|W_c^{(S)}\| = s$.
- Early Stopping

CNN in NLP - Previous Work

- Previous works: NLP from scratch (Collobert et al. 2011).
- Sentence or paragraph modelling using words as input (Kim 2014; Kalchbrenner, Grefenstette, and Blunsom 2014; Johnson and T. Zhang 2015a; Johnson and T. Zhang 2015b).
- Text classification using characters as input (Kim et al. 2016; X. Zhang, Zhao, and LeCun 2015)

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Collobert, Ronan et al. (2011). "Natural language processing (almost) from scratch". In: *Journal of Machine Learning Research* 12.Aug, pp. 2493–2537.

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Zhang, Xiang, Junbo Zhao, and Yann LeCun (2015). "Character-level Convolutional Networks for Text Classification". In: *Advanced in Neural Information Processing Systems (NIPS 2015)*. Vol. 28.