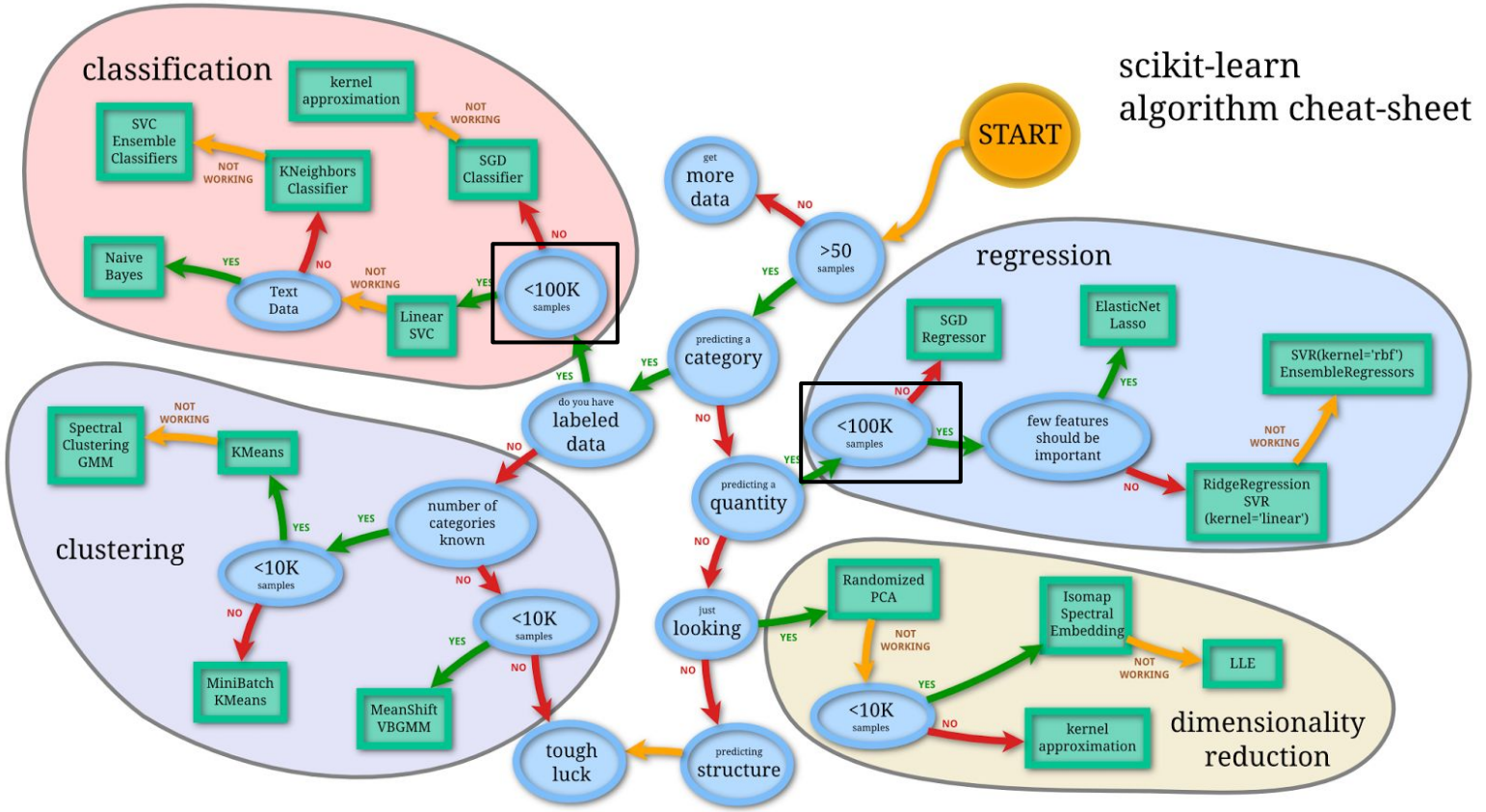
CNN

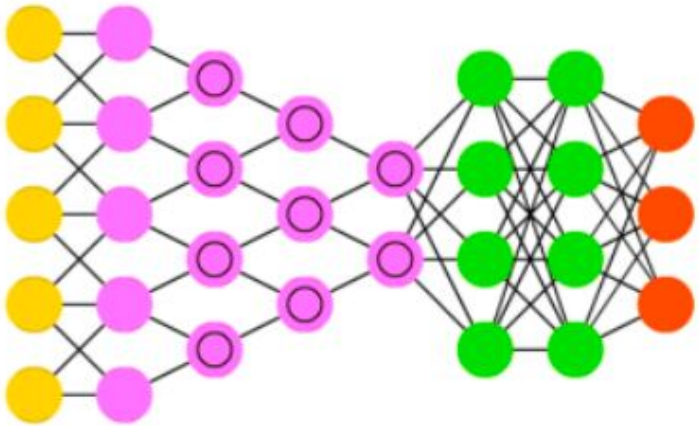
Juan Luis García Mendoza, Mario Ezra Aragón, Adrián Pastor López Monroy, Luis Villaseñor Pineda, Manuel Montes y Gómez

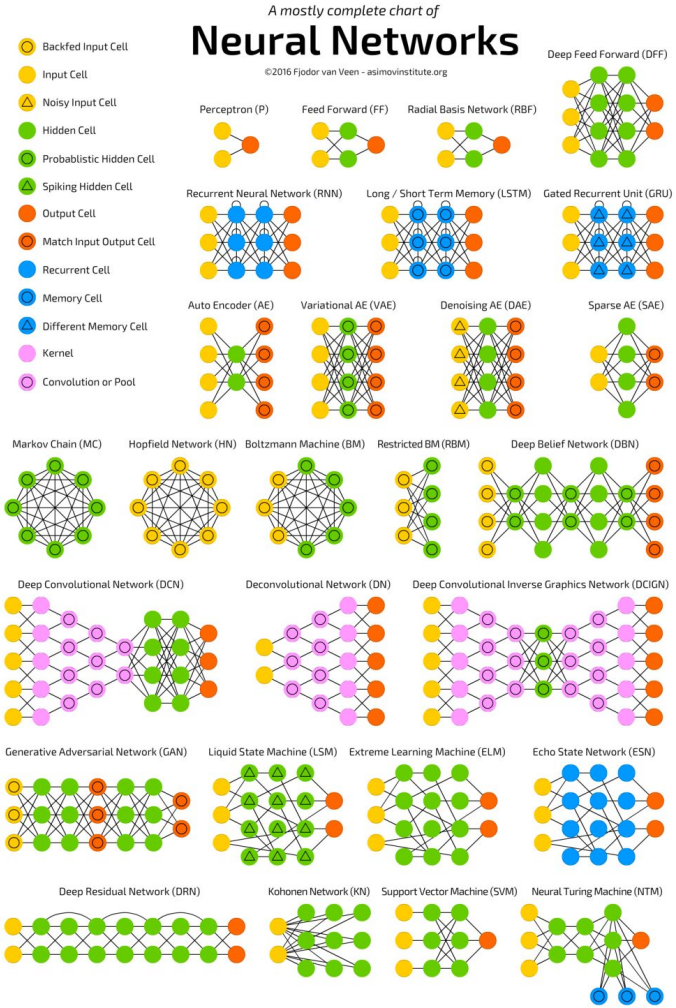
Overview

- Explaining How Convolutions Work
- Pooling
- CNN in NLP


scikit-learn
algorithm cheat-sheet
START
classification
kernel approximation
NOT WORKING
SVC Ensemble Classifiers
NOT WORKING
KNeighbors Classifier
SGD Classifier
NO
Naive Bayes
YES
Text Data
NO
NOT WORKING
Linear SVC
YES
<100K samples
NO
get more data
NO
>50 samples
YES
regression
SGD Regressor
ElasticNet Lasso
SVR(kernel='rbf') EnsembleRegressors
predicting a category
YES
NO
<100K samples
NO
YES
few features should be important
YES
NOT WORKING
RidgeRegression SVR (kernel='linear')
NO
YES
do you have labeled data
NO
YES
predicting a quantity
NO
YES
clustering
Spectral Clustering GMM
NOT WORKING
KMeans
YES
number of categories known
YES
NO
<10K samples
YES
NO
<10K samples
NO
MiniBatch KMeans
MeanShift VBGMM
just looking
NO
YES
Randomized PCA
NOT WORKING
Isomap Spectral Embedding
NOT WORKING
LLE
YES
<10K samples
NO
kernel approximation
dimensionality reduction
tough luck
predicting structure

Deep Convolutional Network (DCN)



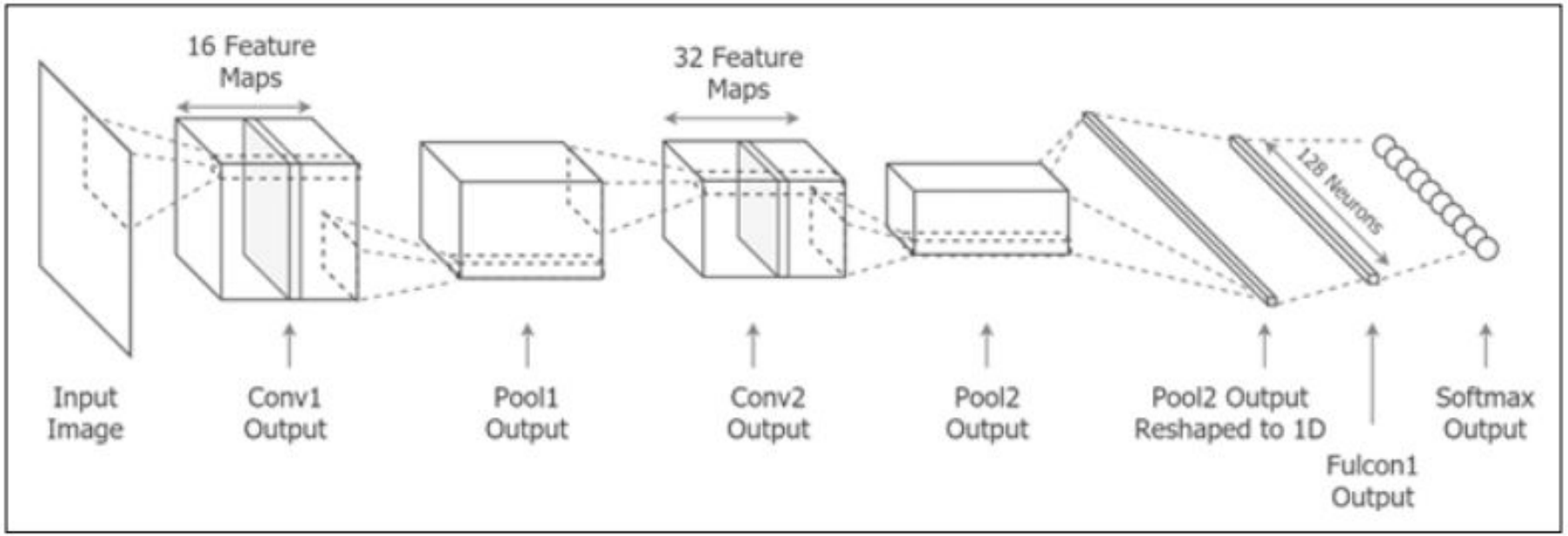


Stefan Kojouharov, Cheat Sheets for AI, Neural Networks, Machine Learning, Deep Learning & Big Data

Terminology

- **filter size:** refers to the window size of the convolution operation
- **stride:** refers to the distance between two movements of the convolution window
- **padding:** refers to the way you handle boundaries of the input
- **pooling operation:** was introduced to CNNs mainly for reducing the size of the intermediate outputs.

Architecture



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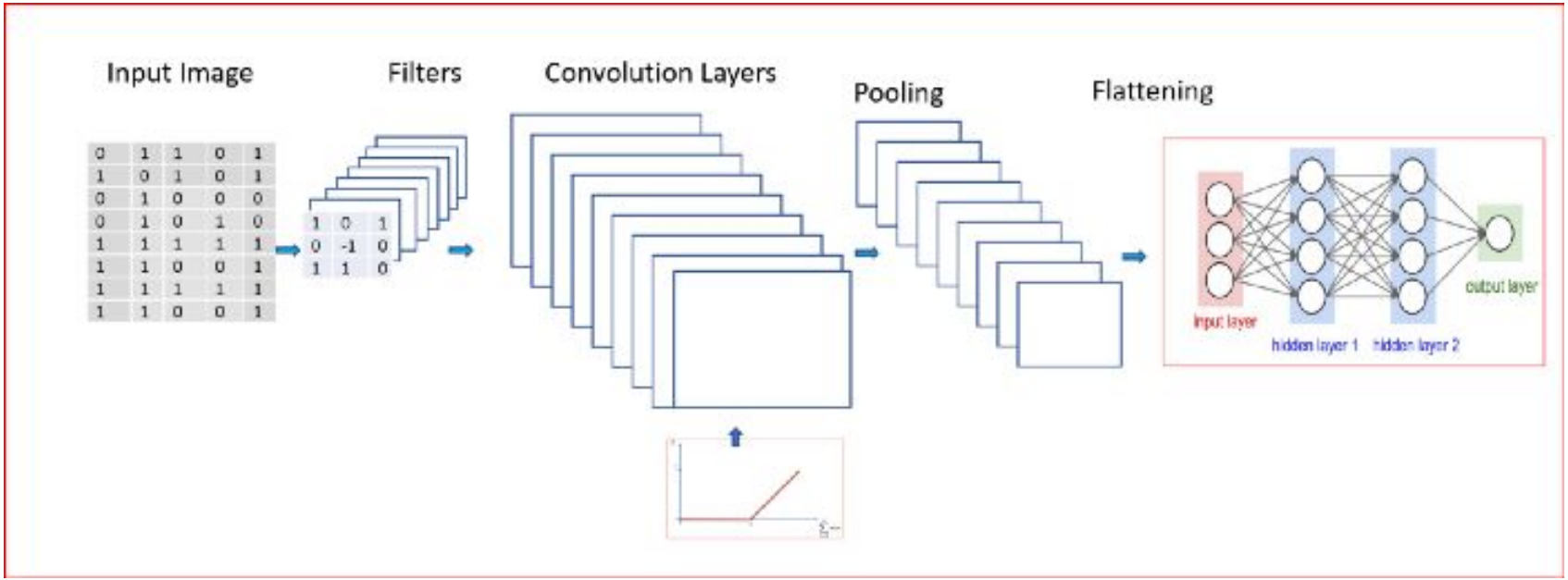
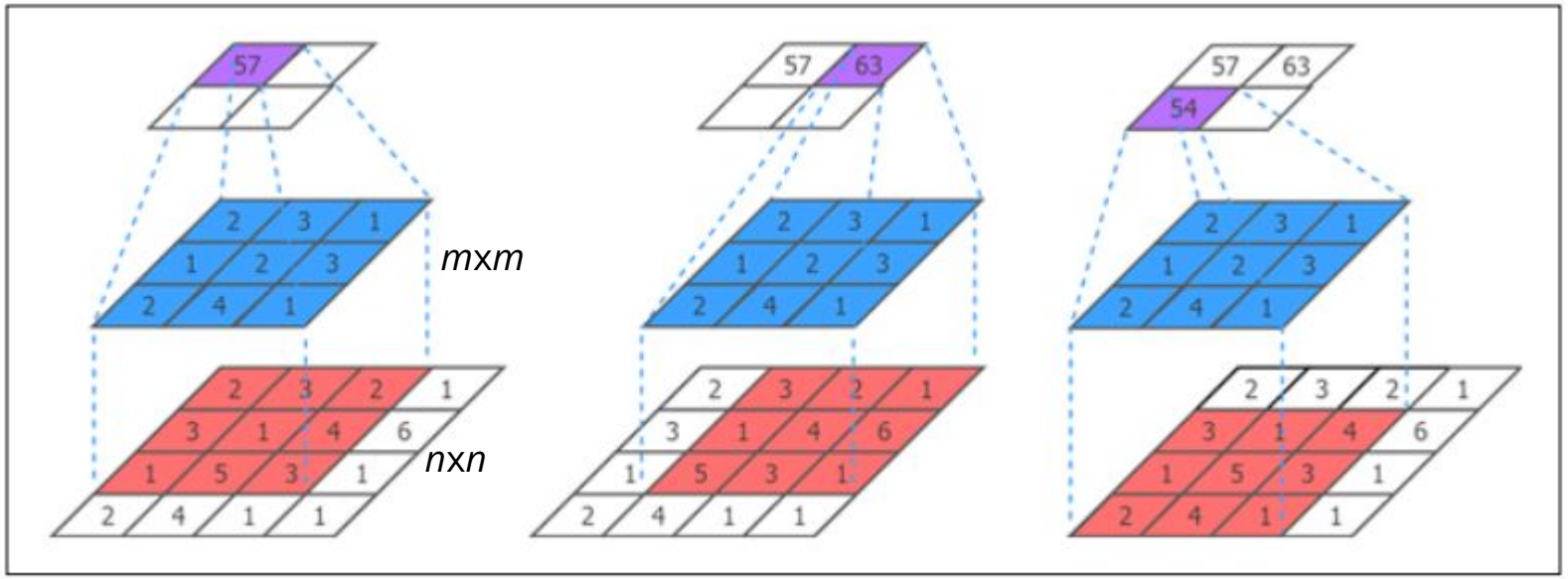
Architecture



Renu Khandelwal, Convolutional Neural Network: Feature Map and Filter Visualization

Standard Convolution



$$h_{i,j} = \sum_{k=1}^{m}\sum_{l=1}^{m} w_{k,l} x_{i+k-1,j+l-1} \; where 1 \le i, j \le n-m+1$$

filter size (m) = 3, stride = 1, padding = None

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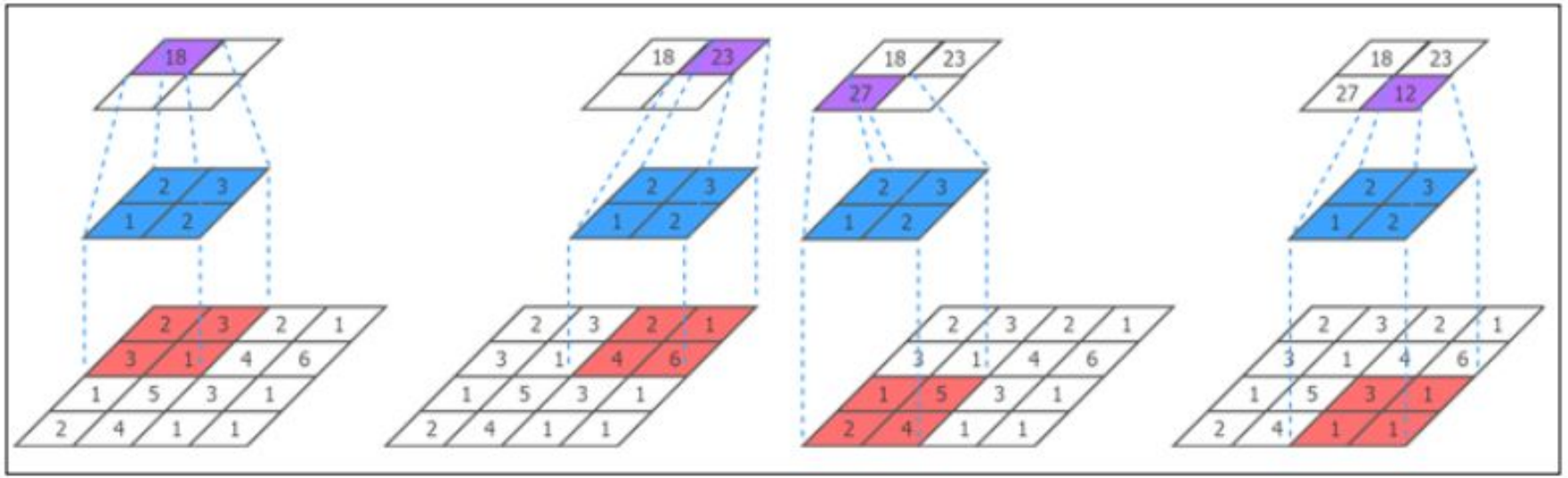
Convolution with stride



$$h_{i,j} = \sum_{k=1}^{m}\sum_{l=1}^{m} w_{k,l}\, x_{(i-1)\times s_i + k,(j-1)\times s_j + l} \; where \; 1 \le i \le floor\left[(n-m)/s_i\right] + 1 \; and \; floor\left[(n-m)/s_j\right] + 1$$

filter size (m) = 2, stride = 2, padding = None

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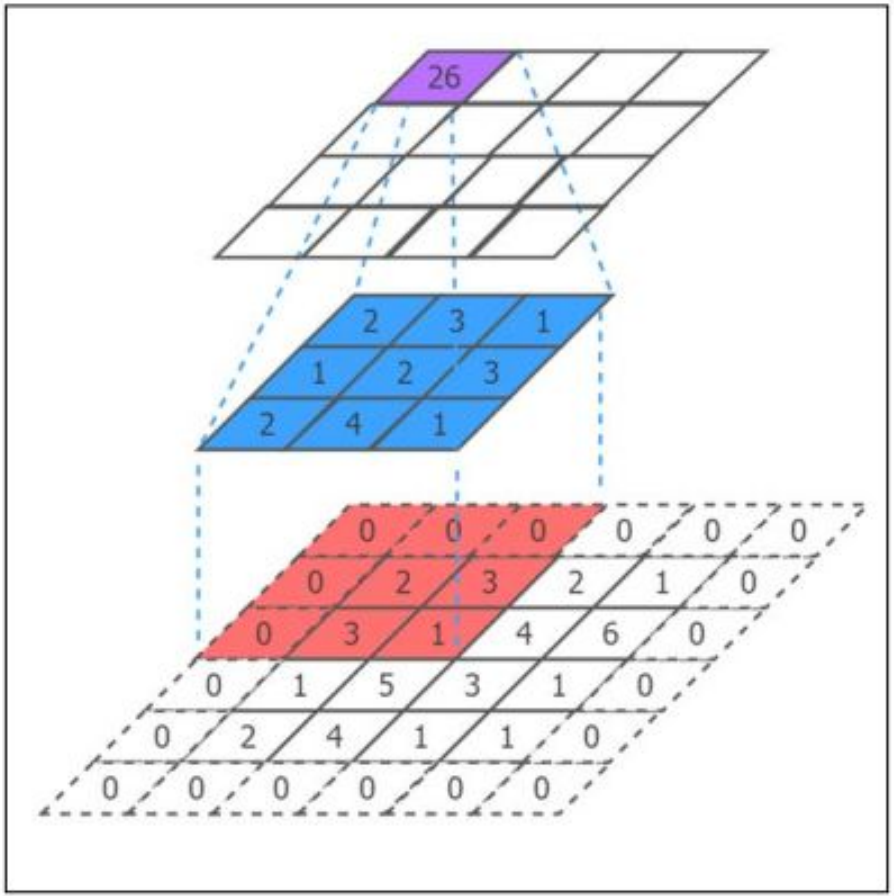
Convolution with padding



$$h_{i,j} = \sum_{k=1}^{m}\sum_{l=1}^{m} w_{k,l} x_{i+k-(m-1),j+l-(m-1)} \; where 1 \le i,j \le n$$

filter size (m) = 3, stride = 1, padding = zero

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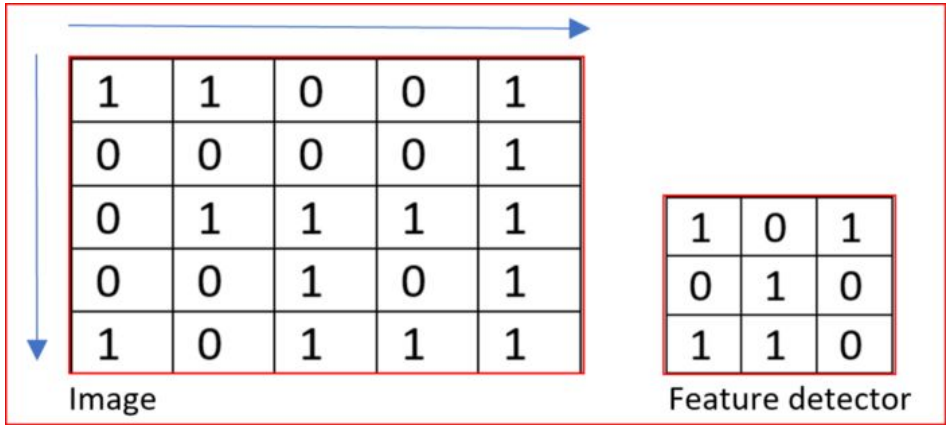
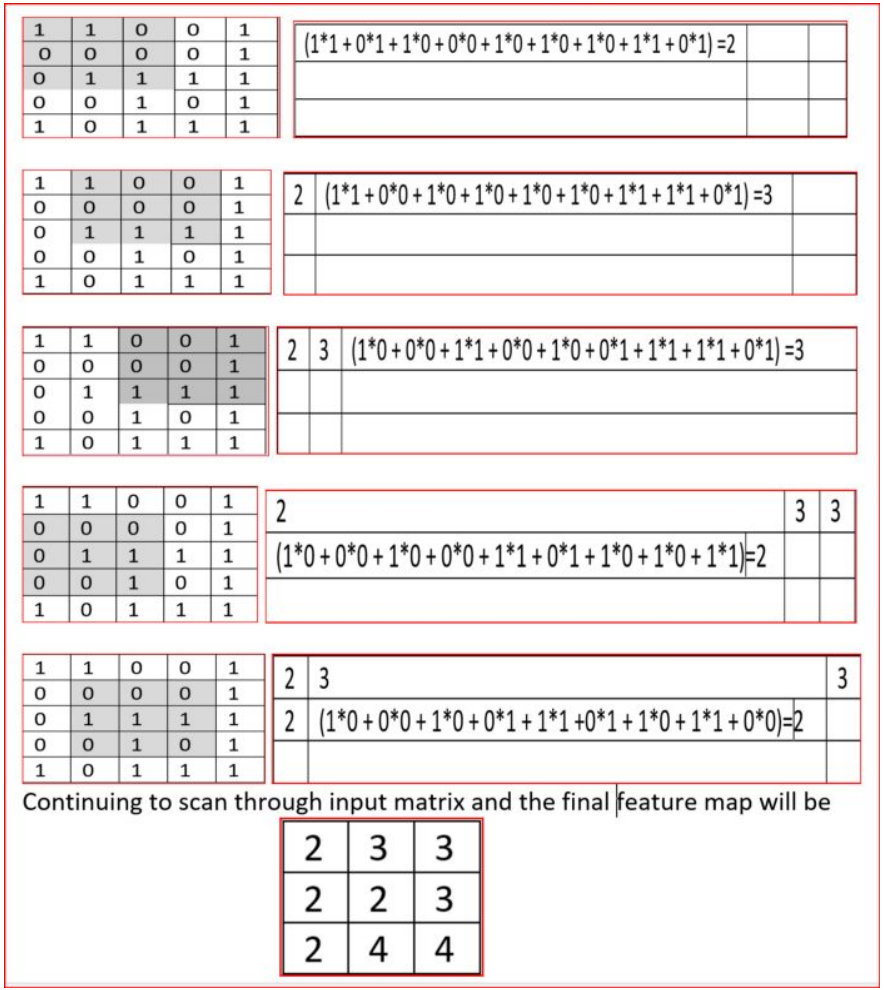
Convolution (example)

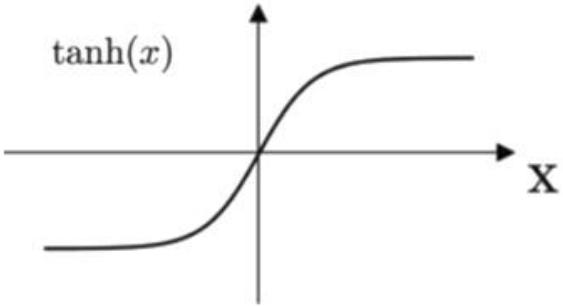


filter size (m) =**?**, stride = **?**, padding = **?**

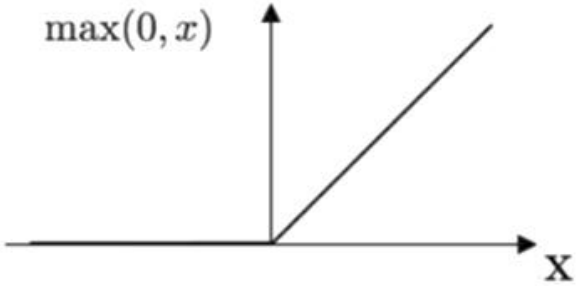


Activation functions

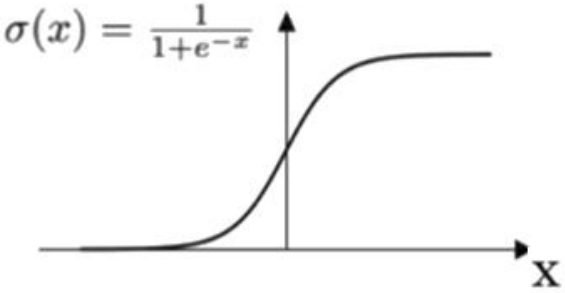
Tanh



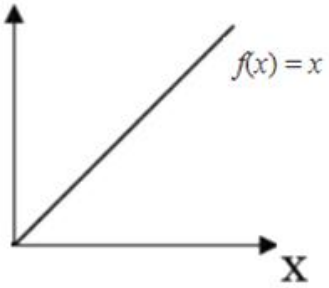
ReLU



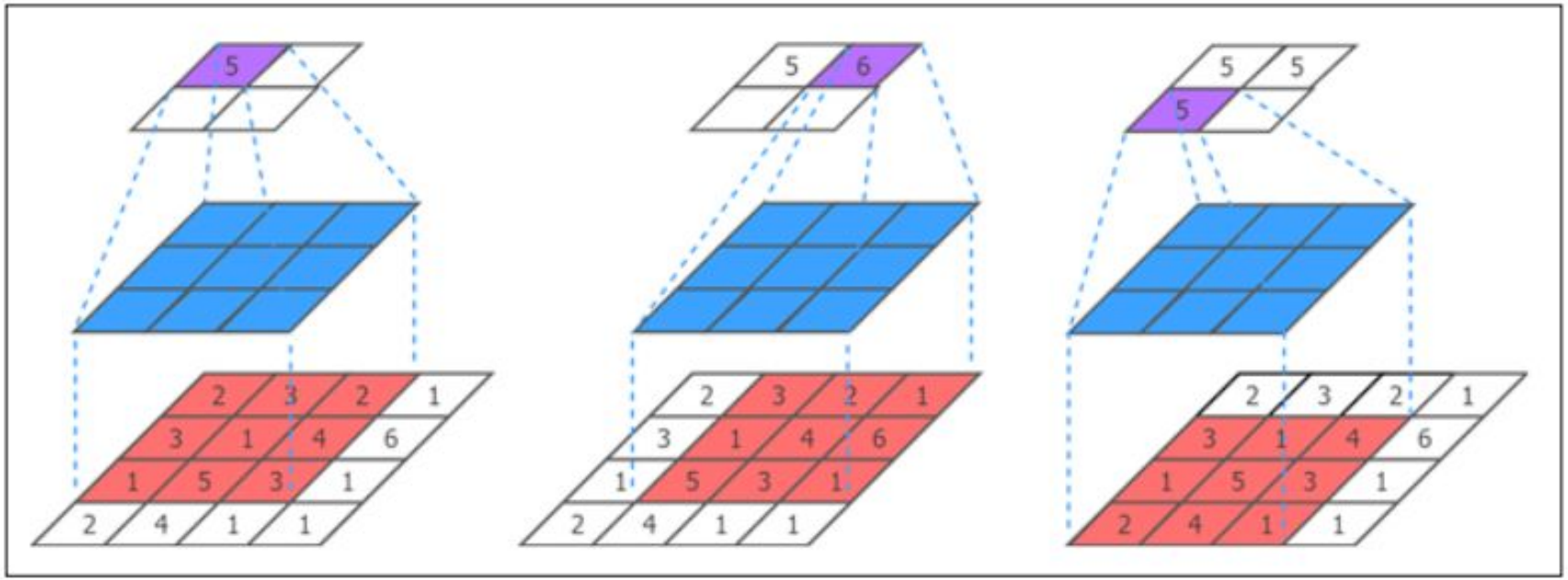
Sigmoid



Linear



Pooling operation



$$h_{i,j} = \max\left(\left\{x_{i,j}, x_{i,j+1}, \ldots, x_{i,j+m-1}, x_{i+1,j}, \ldots, x_{i+1,j+m-1}, \ldots, x_{i+m-1,j}, \ldots, x_{i+m-1,j+m-1}\right\}\right) where 1 \le i, j \le n-m+1$$

filter size (m) = 3, stride = 1, padding = zero

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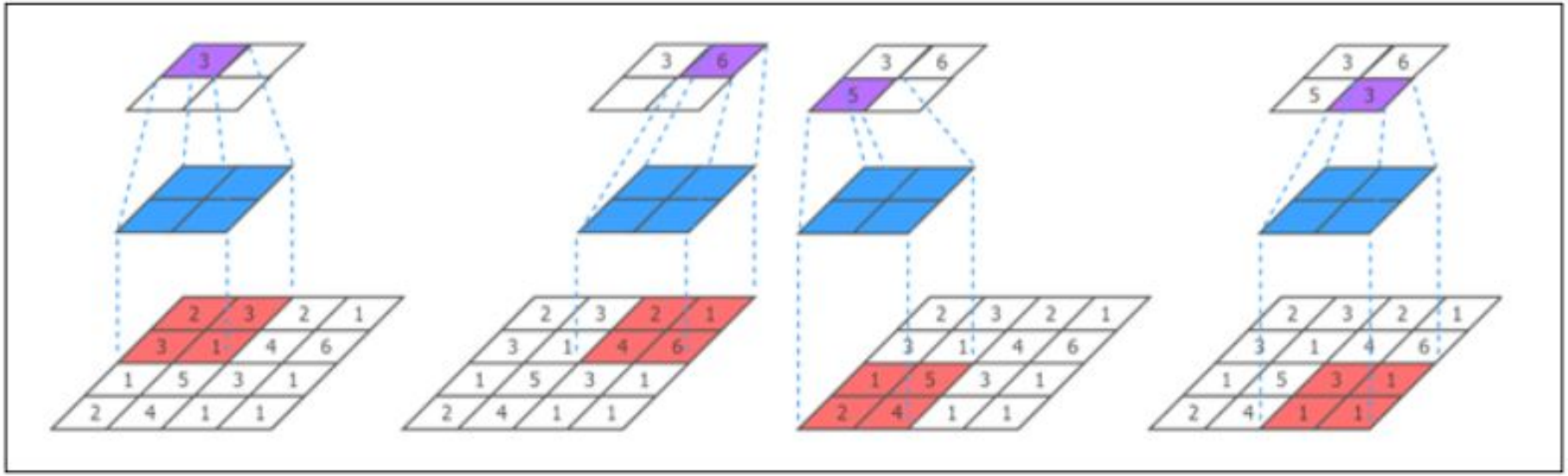
Max pooling with stride



$$h_{i,j} = max\left(\left\{x_{(i-1)\times s_i+1,(j-1)\times s_j+1}, x_{(i-1)\times s_i+1,(j-1)\times s_j+2}, \ldots, x_{(i-1)\times s_i+1,(j-1)\times s_j+m}, x_{(i-1)\times s_i+2,(j-1)\times s_j+1}, \ldots, x_{(i-1)\times s_i+2,(j-1)\times s_j+m}, \ldots, x_{(i-1)\times s_i+m,(j-1)\times s_j+1}, \ldots, x_{(i-1)\times s_i+m,(j-1)\times s_j+m}\right\}\right)$$

$$where 1 \le i \le floor\left[(n-m)/s_i\right]+1 and 1 \le j \le floor\left[(n-m)/s_i\right]+1$$

filter size (m) = 2, stride = 2, padding = zero

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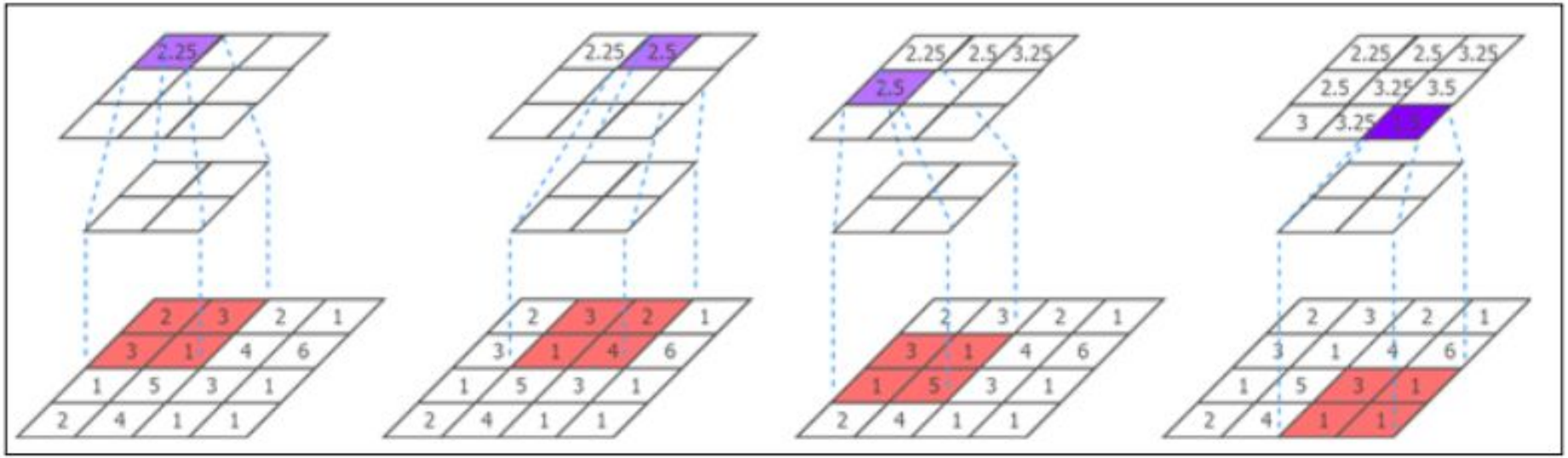
Average pooling



$$h_{i,j} = \frac{x_{i,j}, x_{i,j+1}, \ldots, x_{i,j+m-1}, x_{i+1,j}, \ldots, x_{i+1,j+m-1}, \ldots, x_{i+m-1,j}, \ldots, x_{i+m-1,j+m-1}}{m \times m} \forall i \geq 1, j \leq n - m + 1$$

filter size (m) = 2, stride = 1, padding = zero

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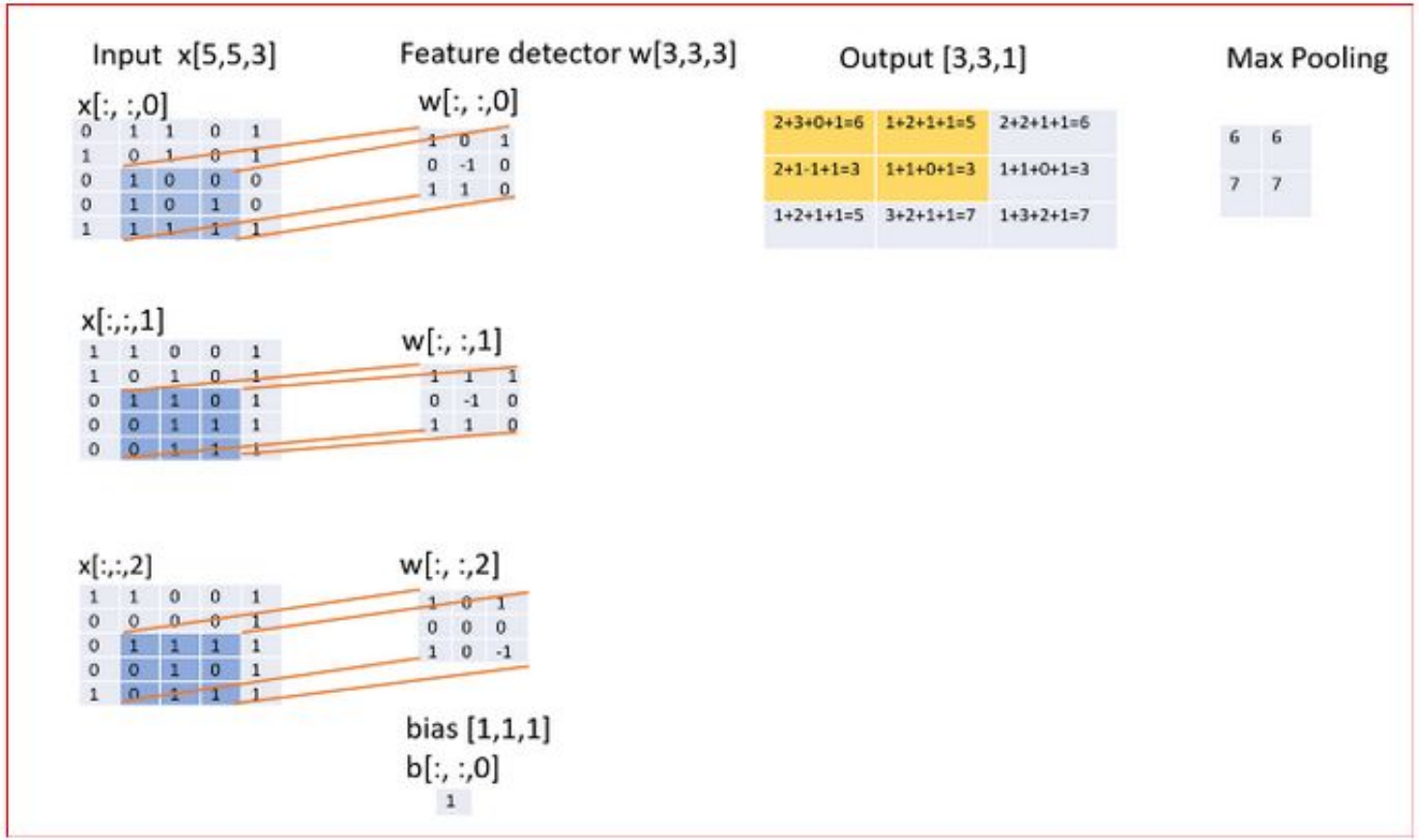
Example



Renu Khandelwal, Convolutional Neural Network(CNN) Simplified

Fully connected layers

- The initial **fully connected layer** found immediately after the **last convolution or pooling layer.**
- The weight matrix will be $w^{(m,\ \boldsymbol{h}x\boldsymbol{w}x\boldsymbol{d})}$.
- During inference (or prediction), we reshape the output of the last convolution/pooling layer to be of size (***h***x***w***x***d***, 1)
- The **output layer** can be a **softmax classification** layer for a classification problem or a **linear layer** for a regression problem.

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CNN in NLP (input)

Let a sentence of **p** words and the length of the input sentences **n** words:

- We will pad the sentence with some special word (if **p< n**).
- We will represent each word in the sentence by a vector of size **k** (one-hot-encoded representation, word2vec, glove).
- A batch of sentences of size b can be represented by a ***b***x***n***x***k*** matrix.

CNN in NLP (input)

k=**13**

Bob and Mary are friends. p=5

Bob plays soccer. p=3

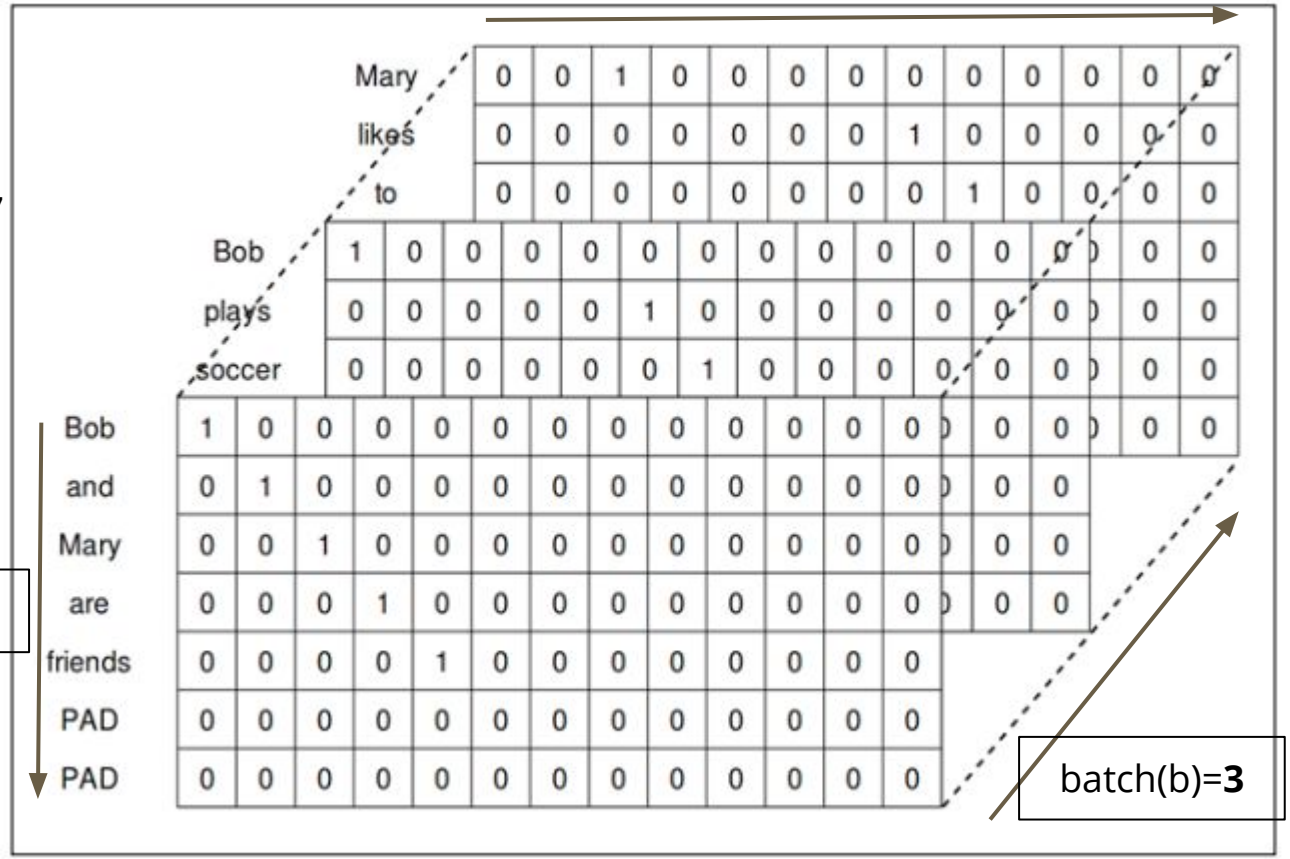
Mary likes to sing in the choir. p=7

special word=**PAD**

word representation: **one-hot**

n=**7**

batch(b)=**3**



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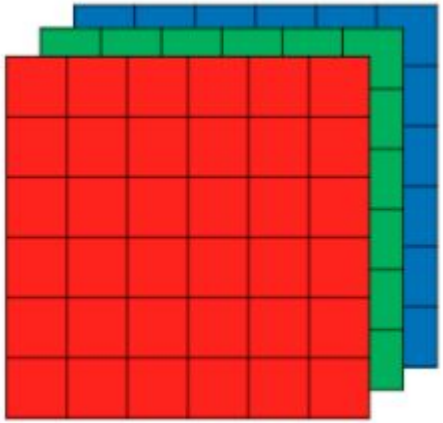
CNN in NLP (convolution operation)

Image



6 x 6 x 3

hx**w**x**d**

Text (one sentence)

Bob	1	0	0	0	0	0	0	0	0	0	0	0	0
and	0	1	0	0	0	0	0	0	0	0	0	0	0
Mary	0	0	1	0	0	0	0	0	0	0	0	0	0
are	0	0	0	1	0	0	0	0	0	0	0	0	0
friends	0	0	0	0	1	0	0	0	0	0	0	0	0
PAD	0	0	0	0	0	0	0	0	0	0	0	0	0
PAD	0	0	0	0	0	0	0	0	0	0	0	0	0

7 x 13

hx**w** -> **n**x**k**

Prabhu, Understanding of Convolutional Neural Network (CNN) — Deep Learning

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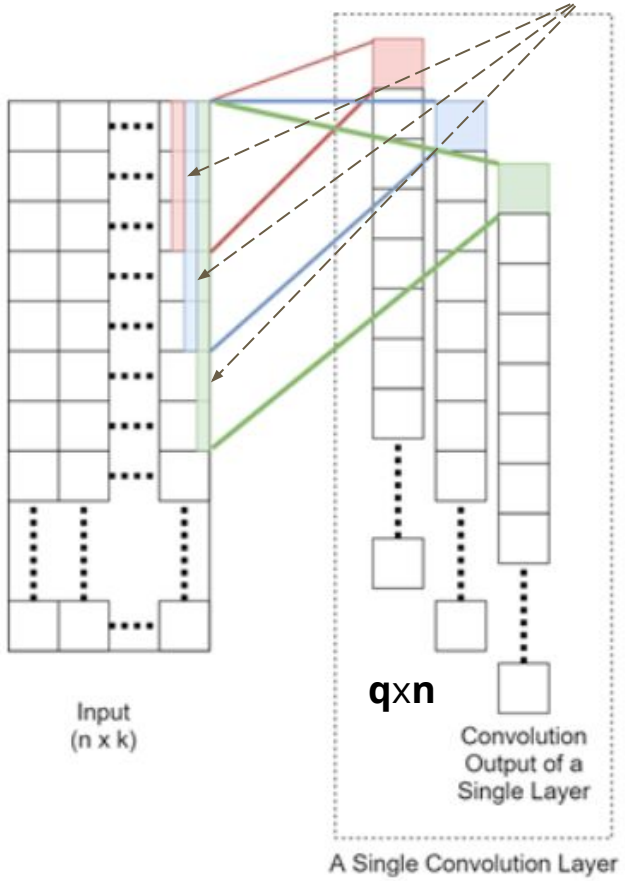
CNN in NLP (convolution operation)

By convolving the input **x** (**n**x**k**) with a weight matrix **W** (**m**x**k**), we will produce an output of **h** (**1**x**n**)

$$h_{i,1} = \sum_{j=1}^{m} \sum_{l=1}^{k} w_{j,l} x_{i+j-1,l} \qquad h = W * x + b$$

- We have parallel layers with different convolution filter sizes.
- Each convolution layer outputs a hidden vector of size **1**×**n**.
- We will concatenate these outputs to form the input to the next layer of size **q**x**n.**
- **q** is the number of parallel layers we will use.



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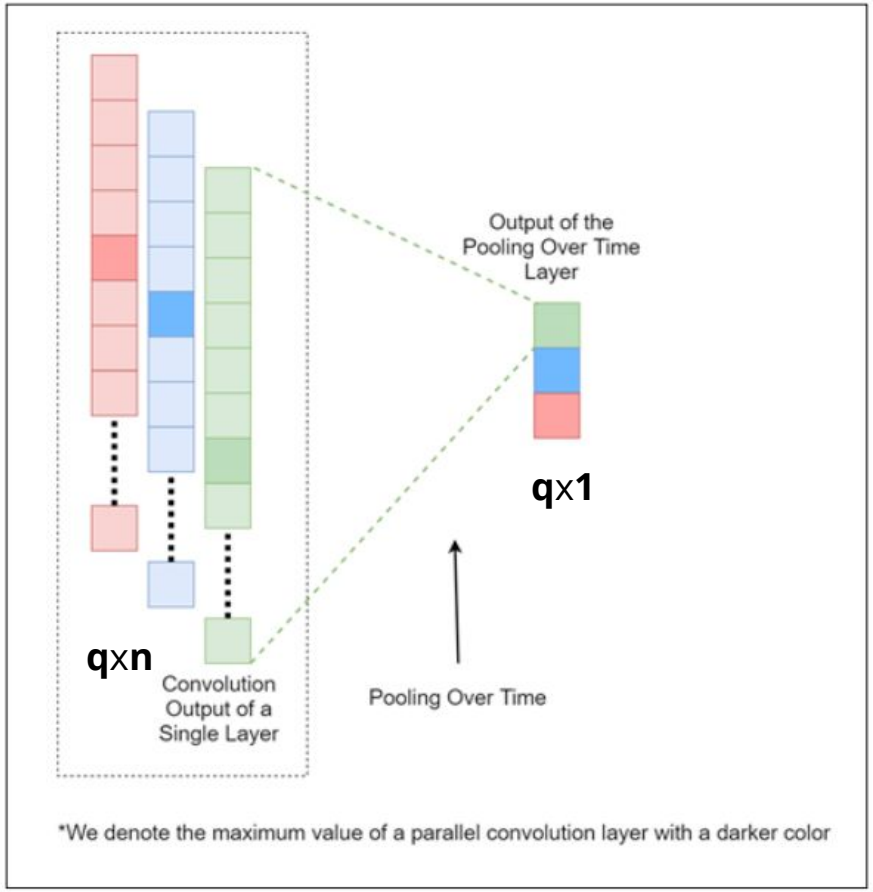
CNN in NLP (pooling operation)

- Let's assume the output of the last layer **h** is of size **q**x**n.**

- The pooling layer would produce an output **h'** of size **q**×**1** output.

$$h_{i,1}' = \left\{ max\left(h^{(i)} \right) where 1 \le i \le q \right\}$$



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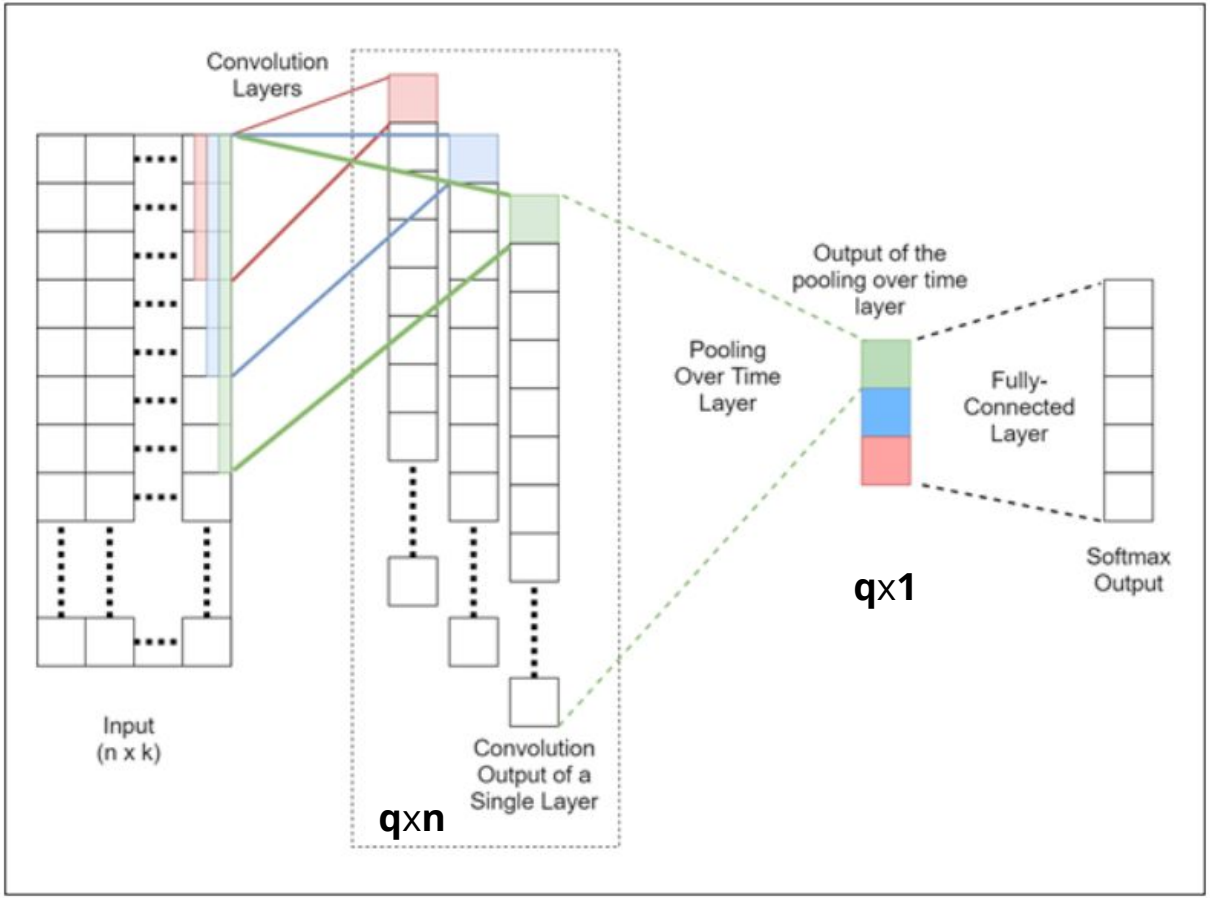
CNN in NLP (architecture)



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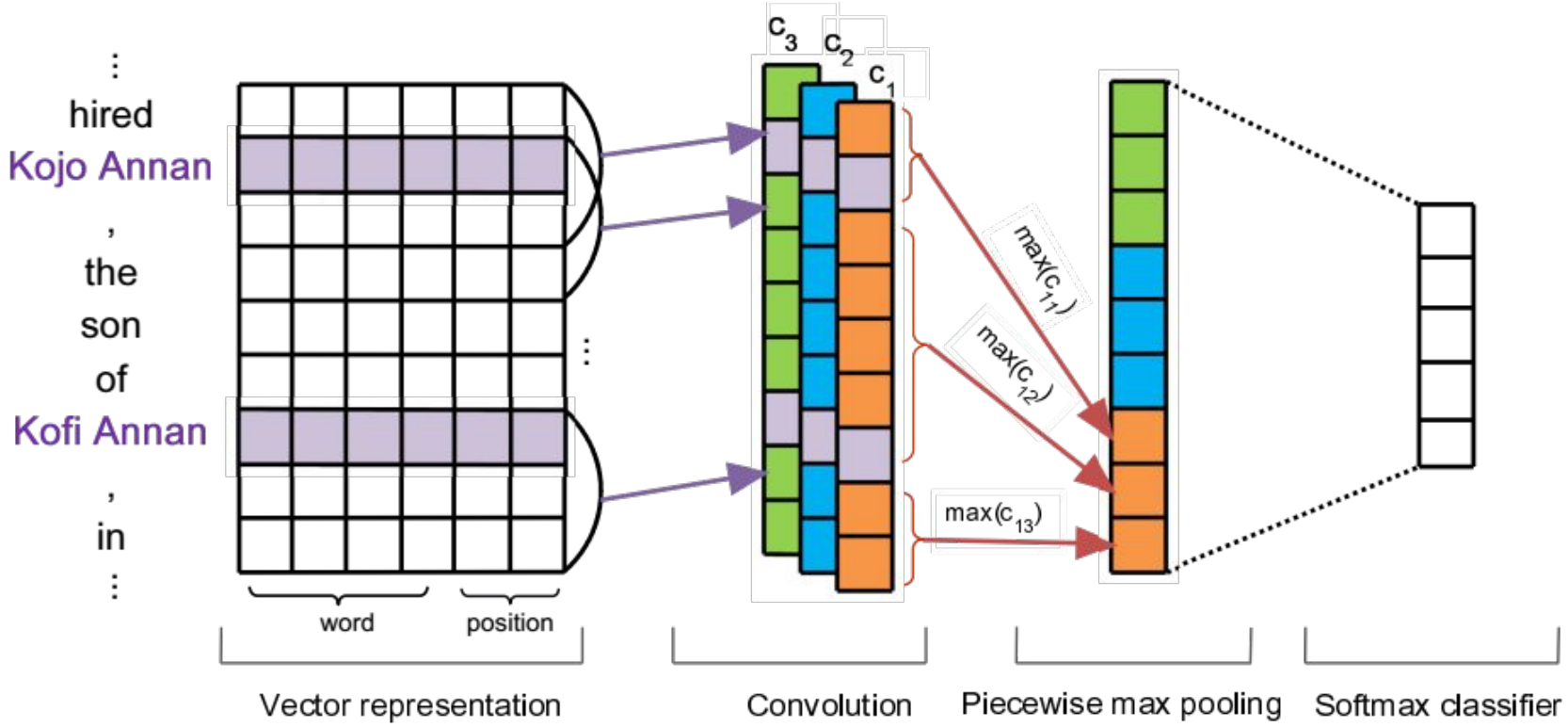
CNN in NLP (relation extraction)



Zeng, D., Liu, K., Chen, Y., & Zhao, J. (2015). Distant supervision for relation extraction via piecewise convolutional neural networks. In Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing (pp. 1753–1762).

References

- Ganegedara, T. (2018). Natural Language Processing with TensorFlow. Packt Publishing Ltd. https://github.com/PacktPublishing/Natural-Language-Processing-with-TensorFlow
- Zeng, D., Liu, K., Chen, Y., & Zhao, J. (2015). Distant supervision for relation extraction via piecewise convolutional neural networks. In Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing (pp. 1753–1762).

Auxiliar Bibliography

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- Renu Khandelwal, Convolutional Neural Network: Feature Map and Filter Visualization
- Renu Khandelwal, Convolutional Neural Network(CNN) Simplified
- Prabhu, Understanding of Convolutional Neural Network (CNN) — Deep Learning
- Activation Function

Questions?

Exercises

- Sentence Classification with CNN (Simple Architecture)
- Sentence Classification with CNN (Complex Architecture)

CNN

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