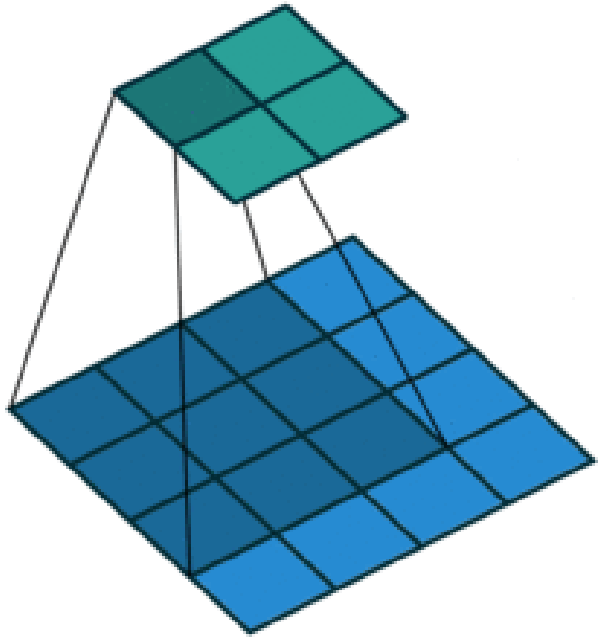
CONVOLUTIONAL NEURAL NETWORKS



Informationsverarbeitung II:
Informationsextraktion mit Neuronalen Netzwerken

Eduard Saller

Overview

- History
- CNN Topology Overview
- Example with step by step introduction of important terms
- CNNs for NLP
- Discussion

History

- Yann LeCun

New York University

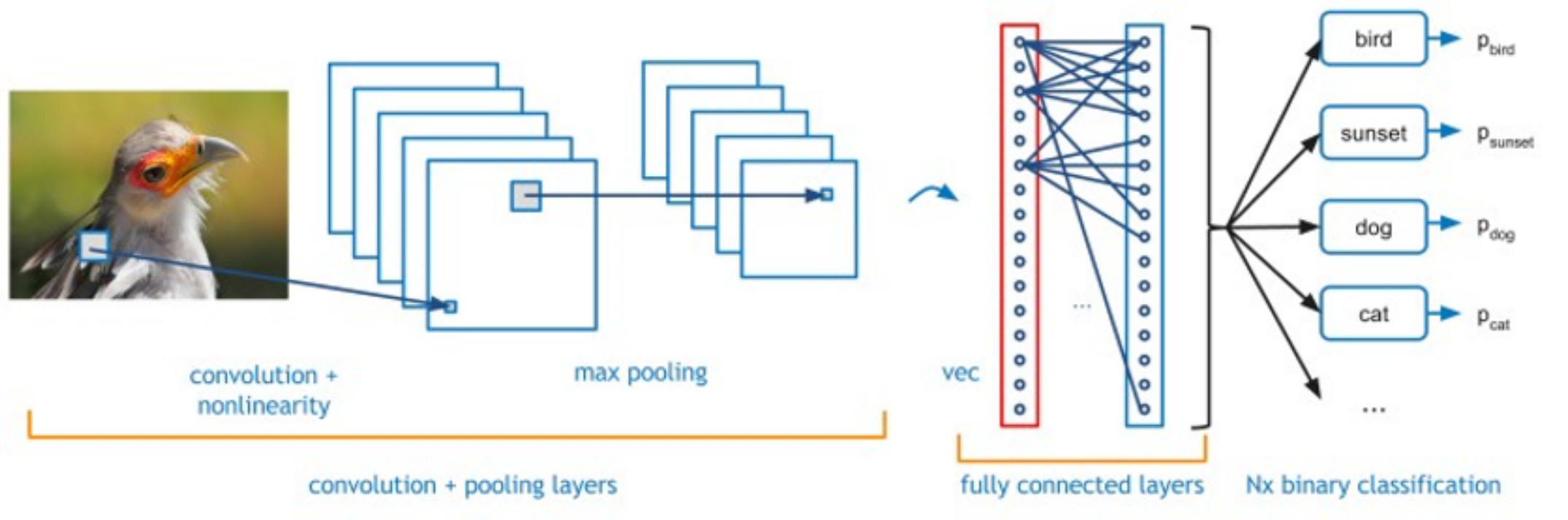
Facebook Artificial Intelligence Research

- Yoshua Bengio

Université de Montréal

- In 1995, Yann LeCun and Yoshua Bengio introduced the concept of convolutional neural networks.

CNN Topology



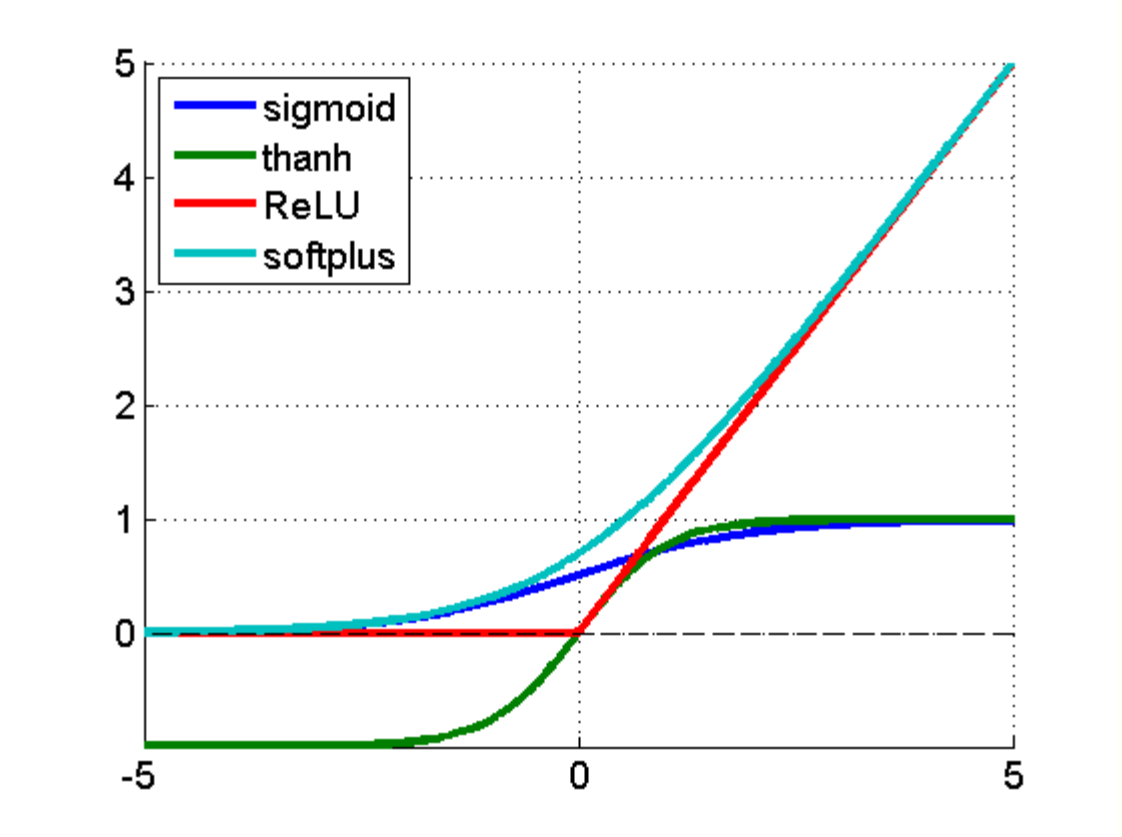
http://www.nallatech.com/fpga-acceleration-convolutional-neural-networks/

Recap: Non-Linearity?

- A neural network is only non-linear if you squash the output signal from the nodes with a non-linear activation function.

  => arbitrary function approximator

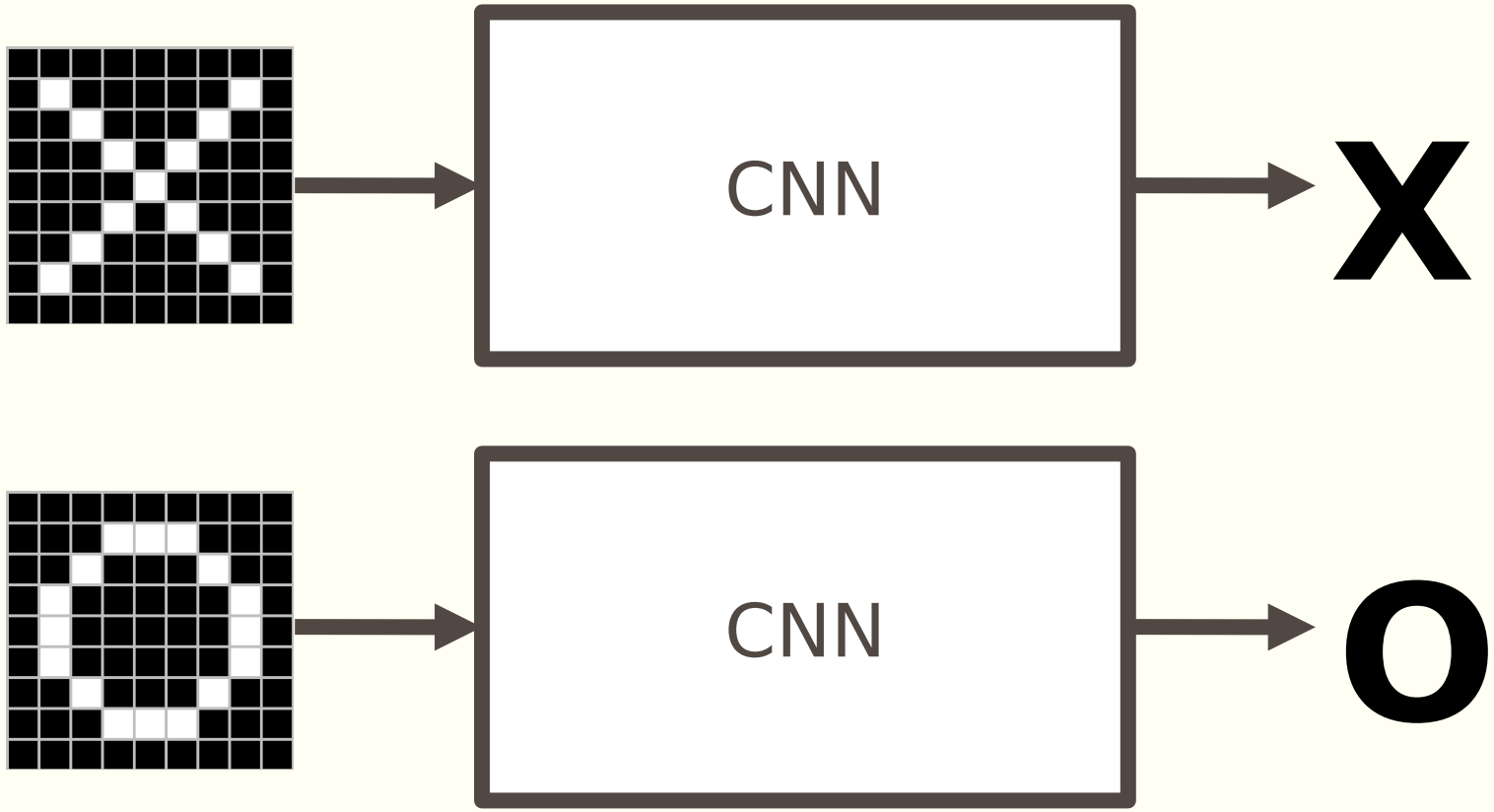
- Interpreting the squashed output signal could very well be interpreted as the strength of this signal (biologically speaking)



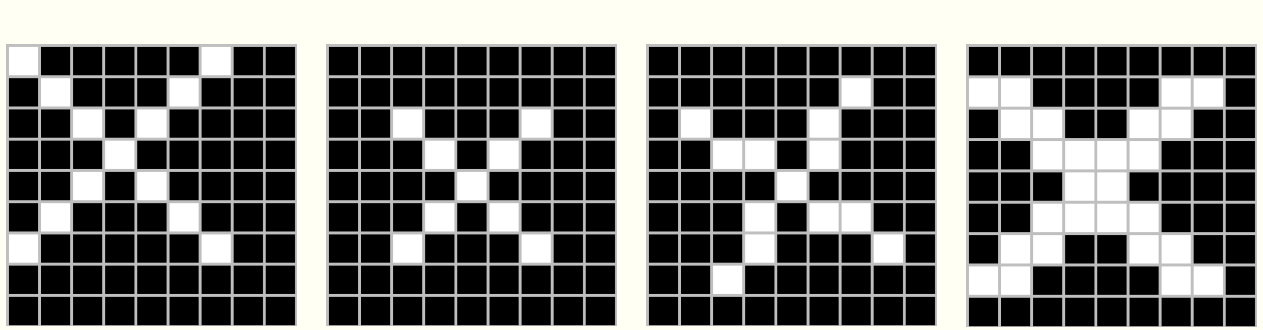
Toy Example

A two-dimensional array of pixels

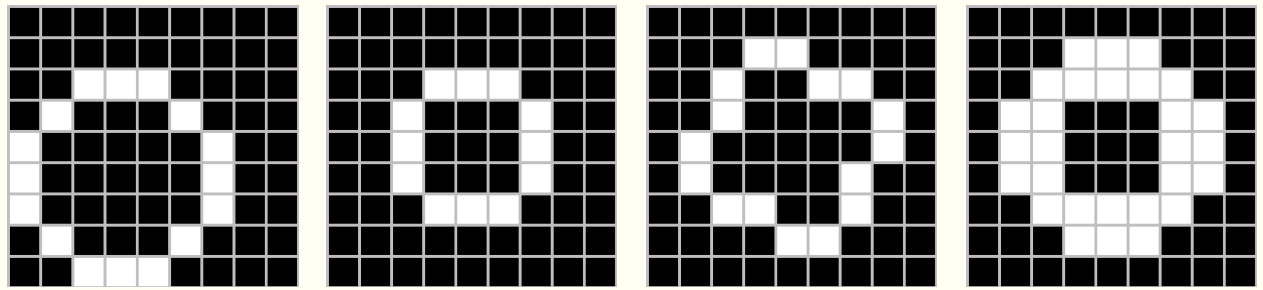
Toy Example



Harder to solve problem



translation scaling rotation weight



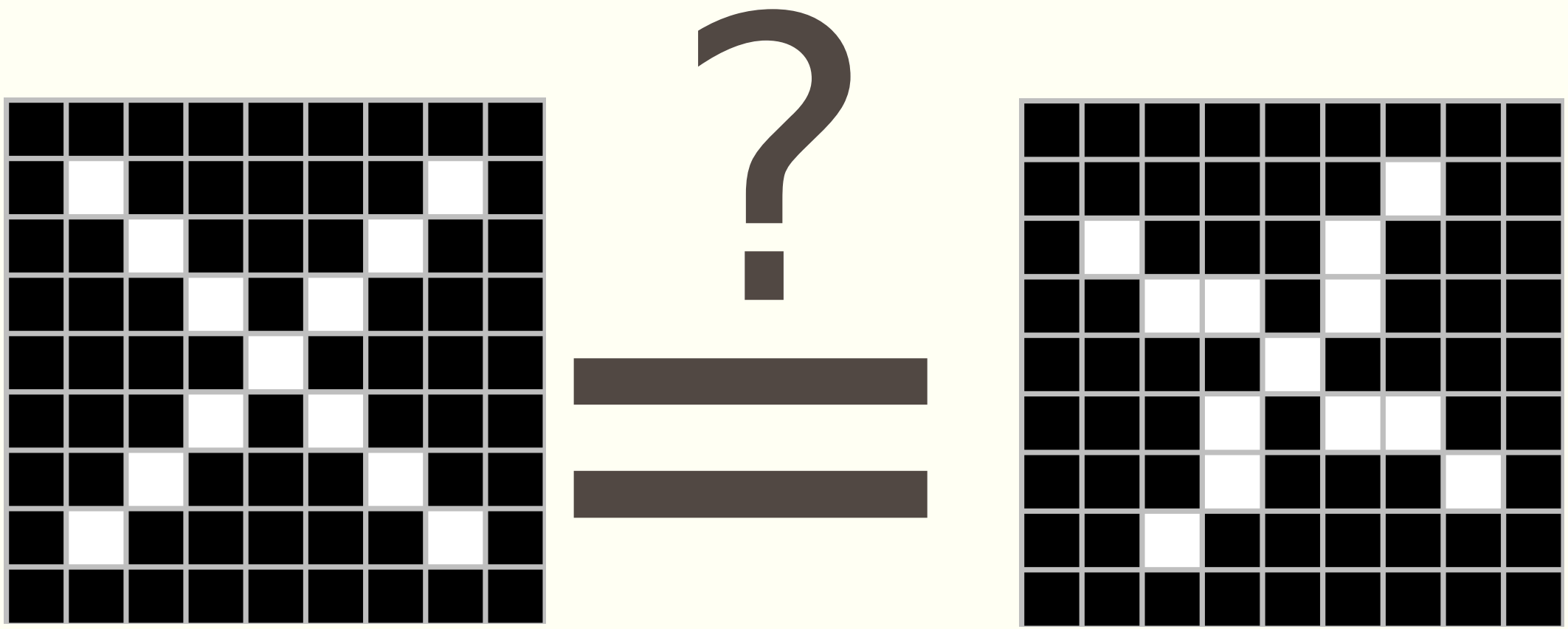
CNN

X

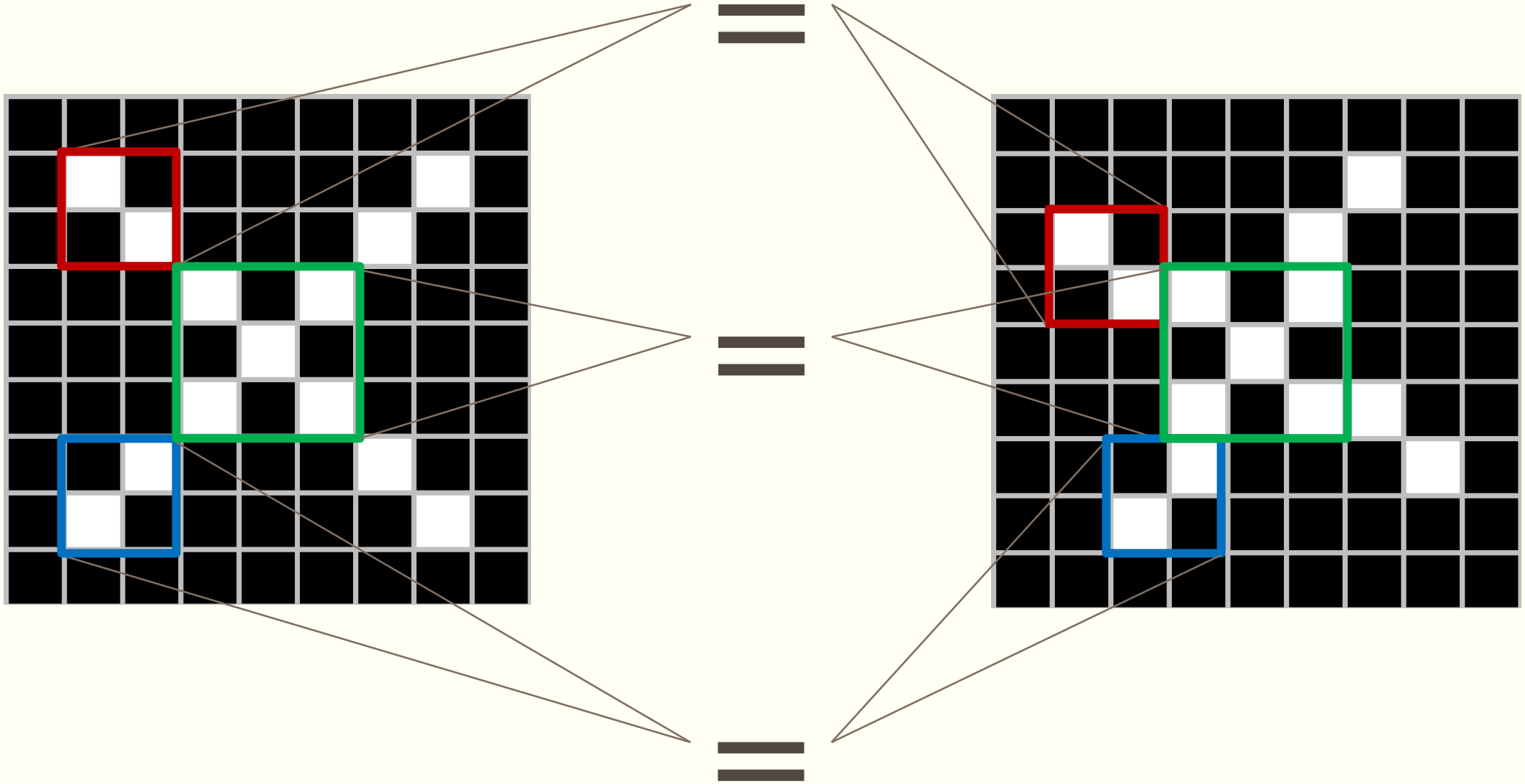
CNN

O

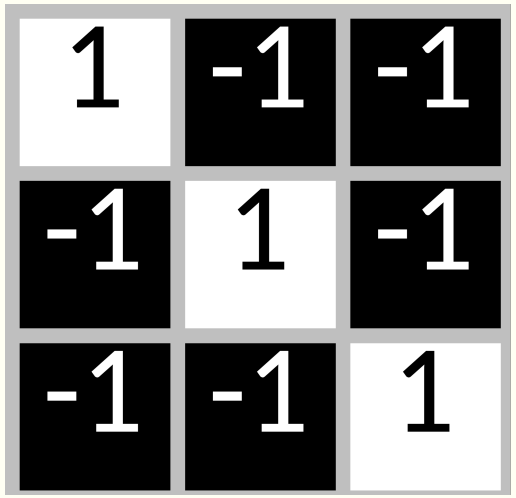
How to compare?

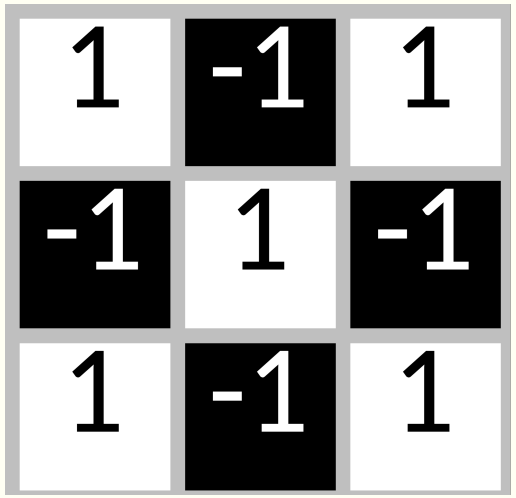


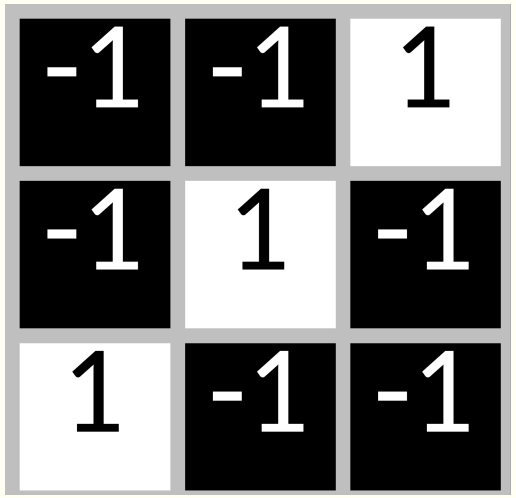
Compare smaller areas



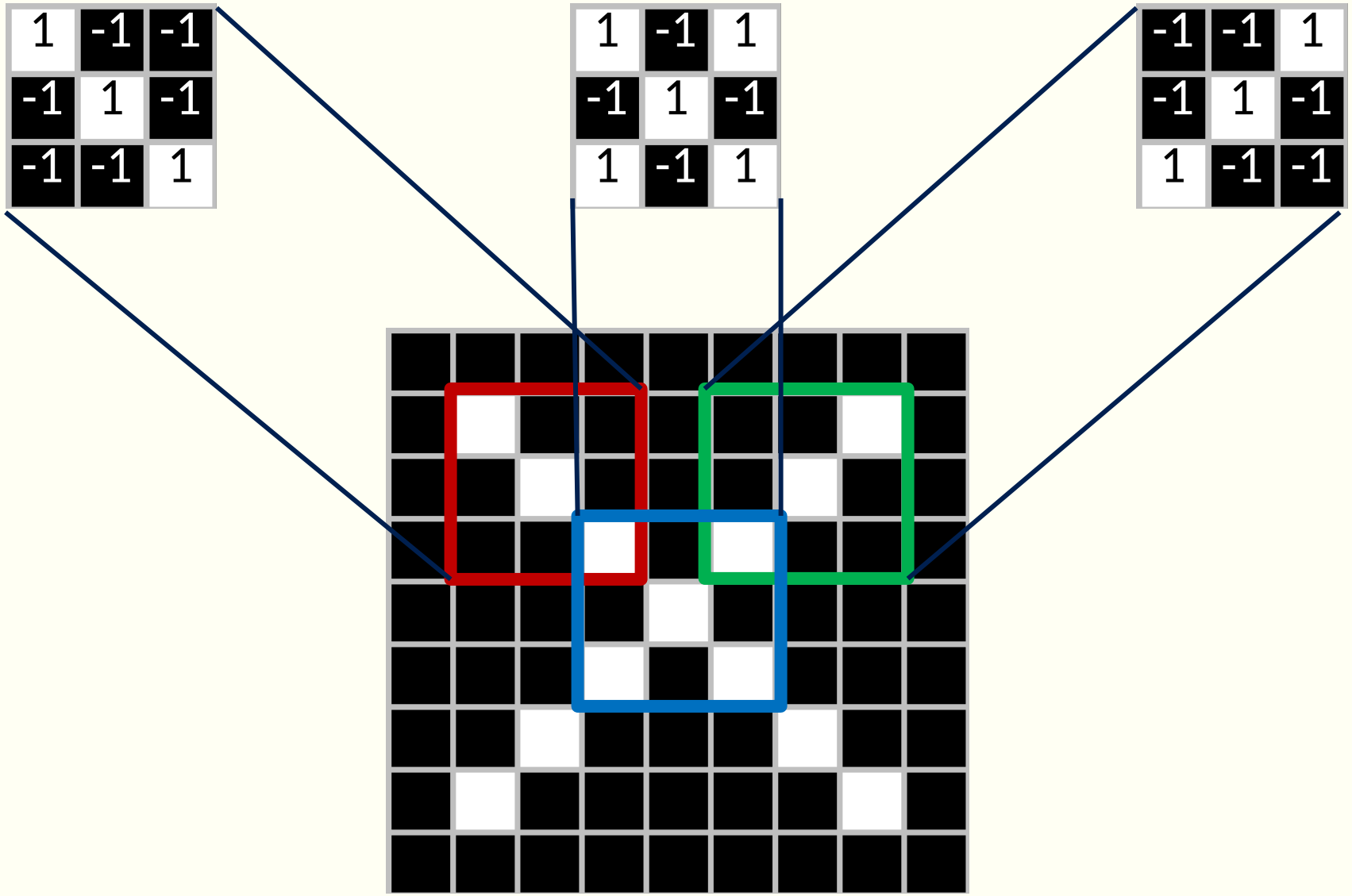
Term: Filter



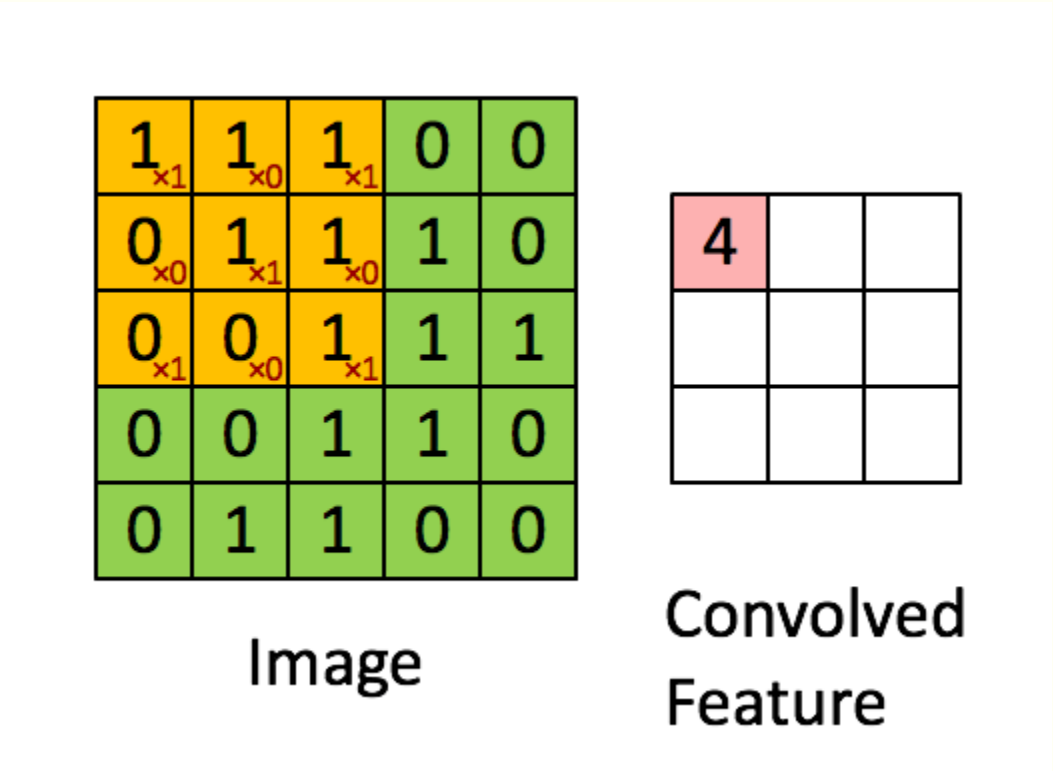




Term: Filter



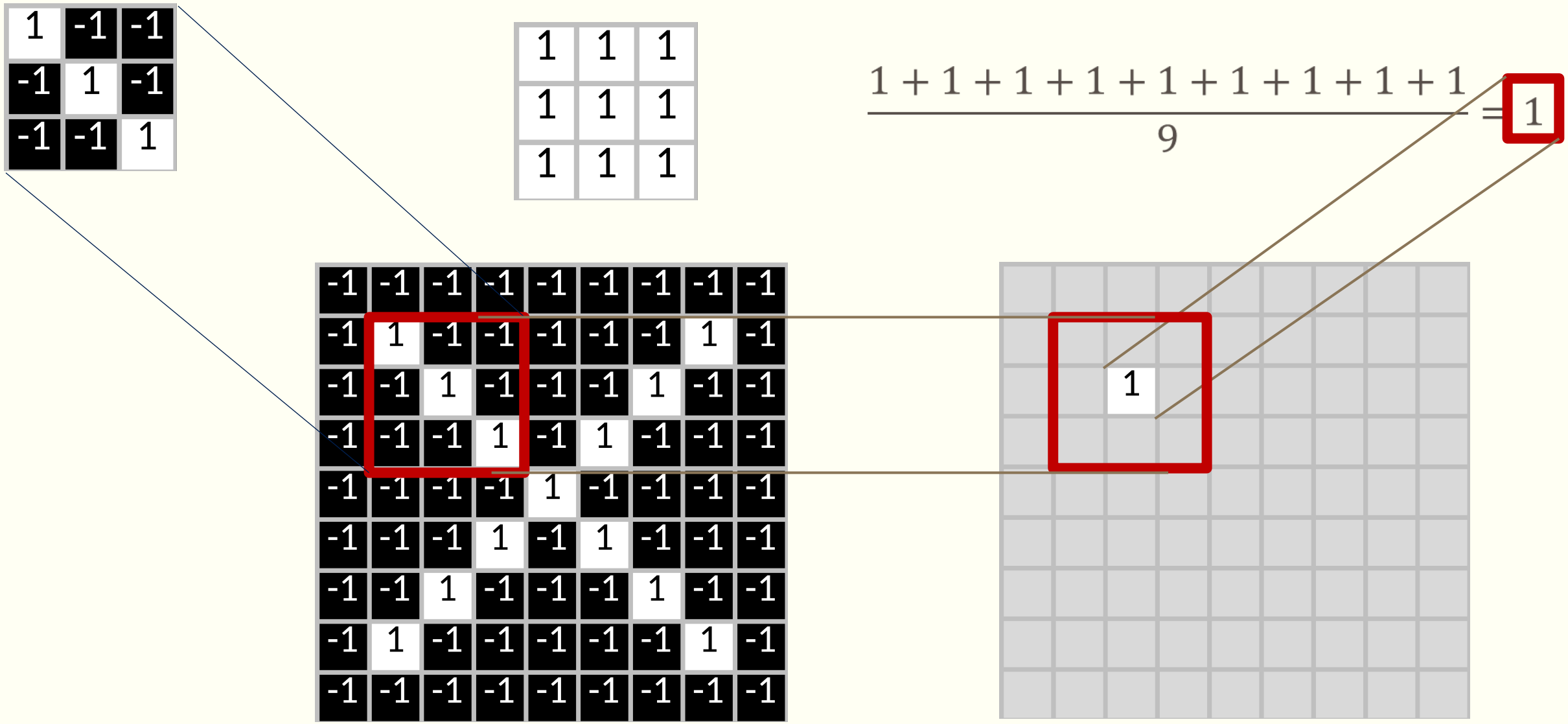
Term: Convolution

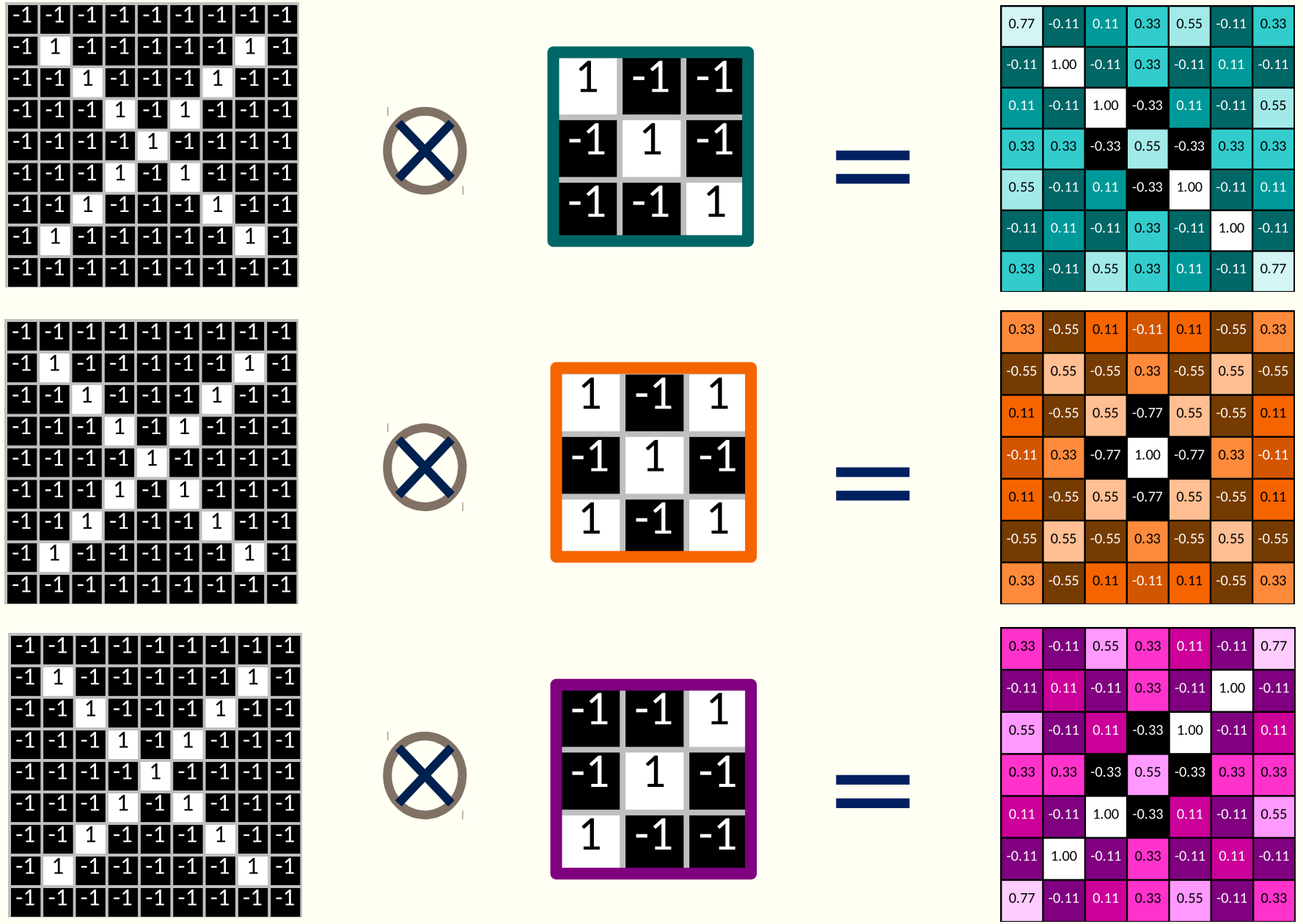


Used fitlers to create a **filter layer** based on the input
- Yellow area: counts all ones that are part of ist diagonal
- Green area: input features

http://deeplearning.stanford.edu/wiki/index.php/Feature_extraction_using_convolution

Building the filter layer

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-1 -1 -1 -1 1 -1 -1 -1 -1
-1 -1 -1 1 -1 1 -1 -1 -1
-1 -1 1 -1 -1 -1 1 -1 -1
-1 1 -1 -1 -1 -1 -1 1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
1 -1 -1
-1 1 -1
-1 -1 1
0.77 -0.11 0.11 0.33 0.55 -0.11 0.33
-0.11 1.00 -0.11 0.33 -0.11 0.11 -0.11
0.11 -0.11 1.00 -0.33 0.11 -0.11 0.55
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-0.55 0.55 -0.55 0.33 -0.55 0.55 -0.55
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1 -1 -1
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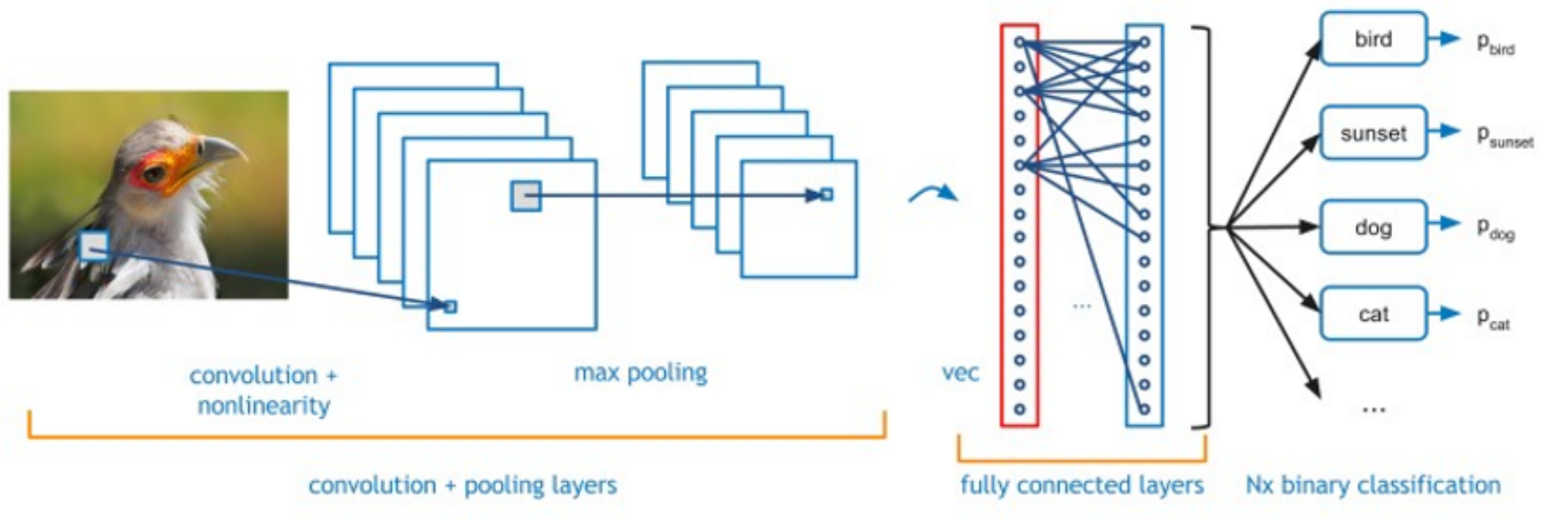
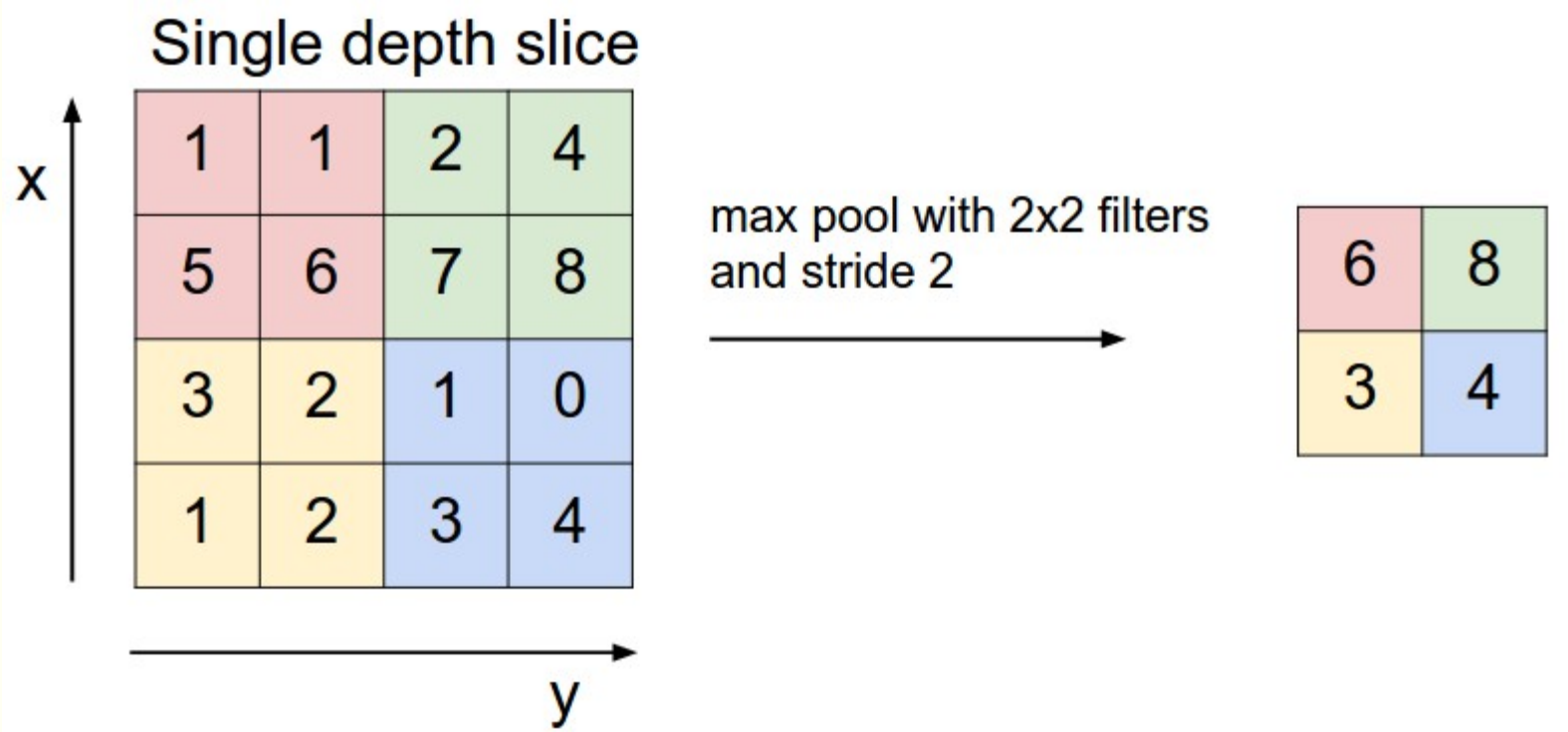
0.55 -0.11 0.11 -0.33 1.00 -0.11 0.11
0.33 0.33 -0.33 0.55 -0.33 0.33 0.33
0.11 -0.11 1.00 -0.33 0.11 -0.11 0.55
-0.11 1.00 -0.11 0.33 -0.11 0.11 -0.11
0.77 -0.11 0.11 0.33 0.55 -0.11 0.33

Recap: CNN Topology

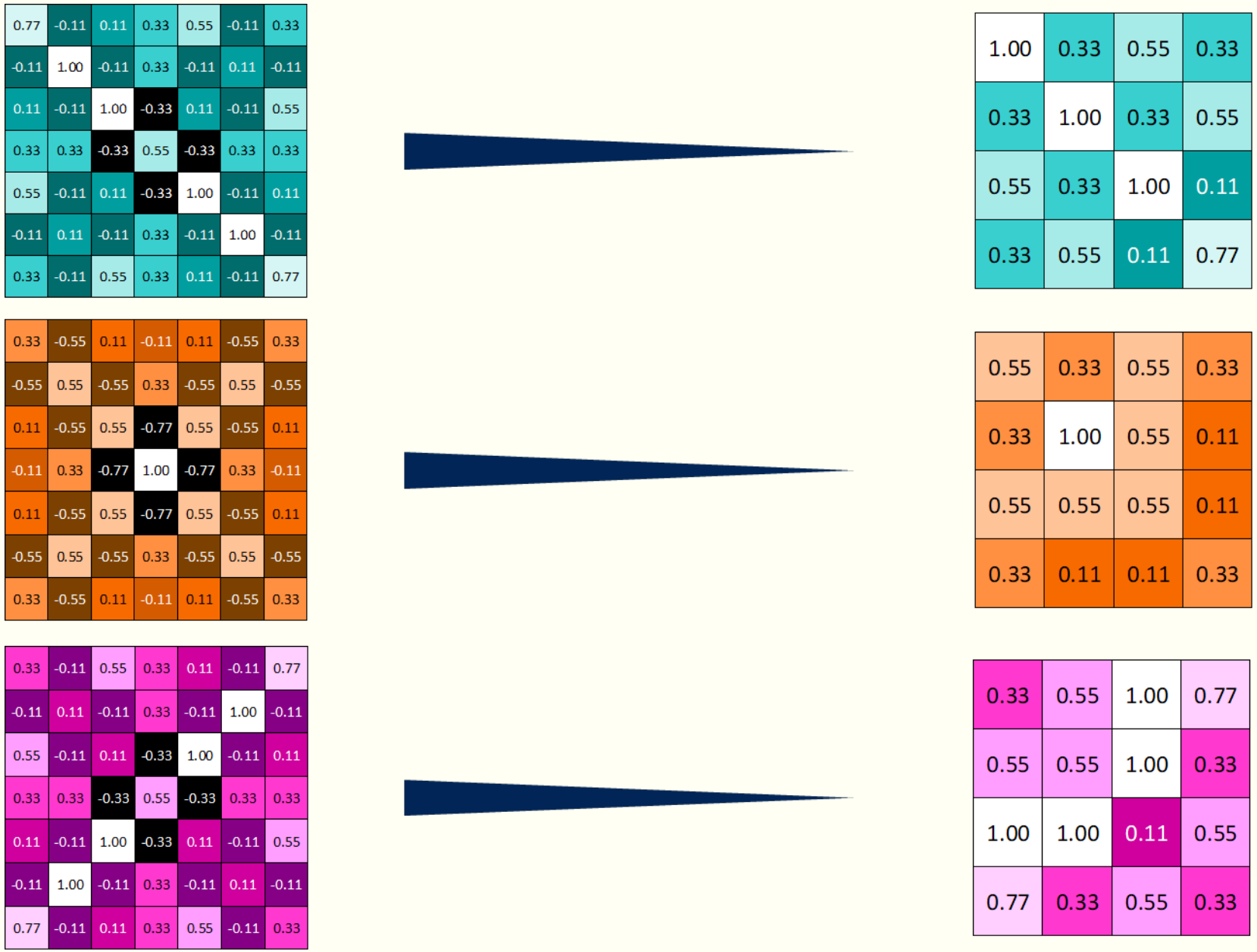


http://www.nallatech.com/fpga-acceleration-convolutional-neural-networks/

Term: Pooling Layers



http://cs231n.github.io/convolutional-networks/#pool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-0.11 1.00 -0.11 0.33 -0.11 0.11 -0.11
0.11 -0.11 1.00 -0.33 0.11 -0.11 0.55
0.33 0.33 -0.33 0.55 -0.33 0.33 0.33
0.55 -0.11 0.11 -0.33 1.00 -0.11 0.11
-0.11 0.11 -0.11 0.33 -0.11 1.00 -0.11
0.33 -0.11 0.55 0.33 0.11 -0.11 0.77
1.00 0.33 0.55 0.33
0.33 1.00 0.33 0.55
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0.33 0.55 0.11 0.77
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-0.55 0.55 -0.55 0.33 -0.55 0.55 -0.55
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-0.11 1.00 -0.11 0.33 -0.11 0.11 -0.11
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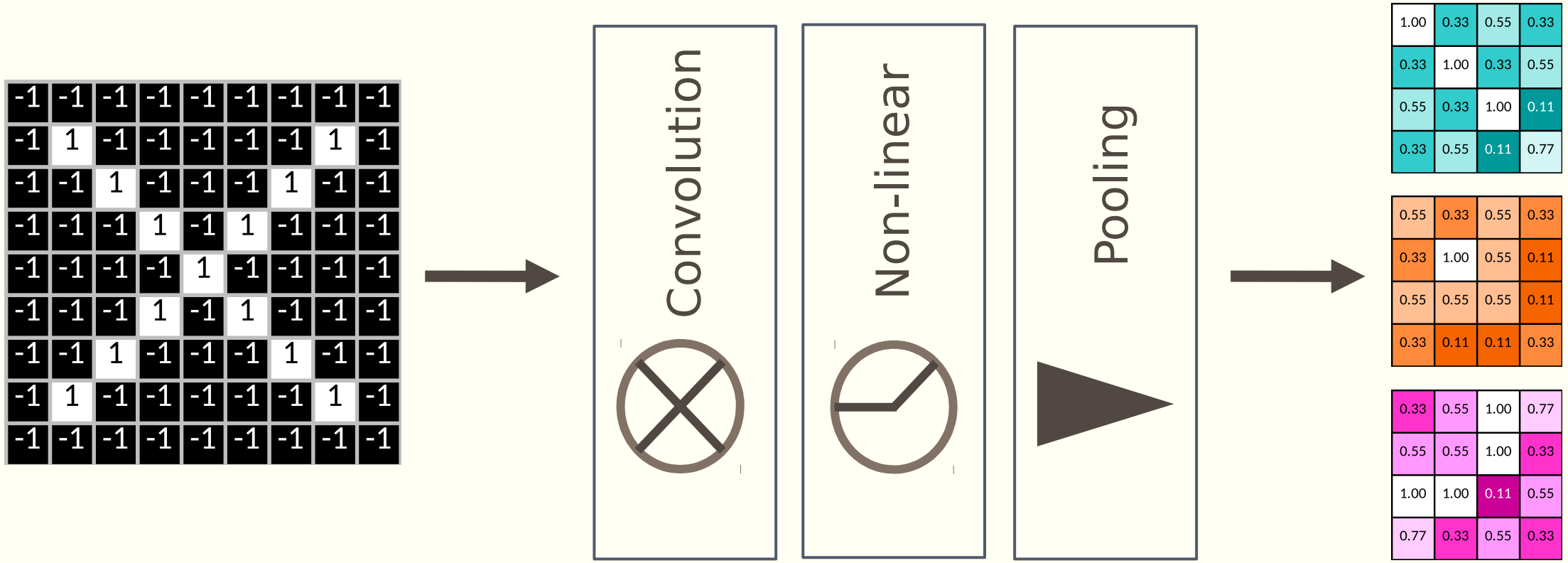
1.00 1.00 0.11 0.55
0.77 0.33 0.55 0.33

Stacking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-1 1 -1 -1 -1 -1 -1 1 -1
-1 -1 1 -1 -1 -1 1 -1 -1
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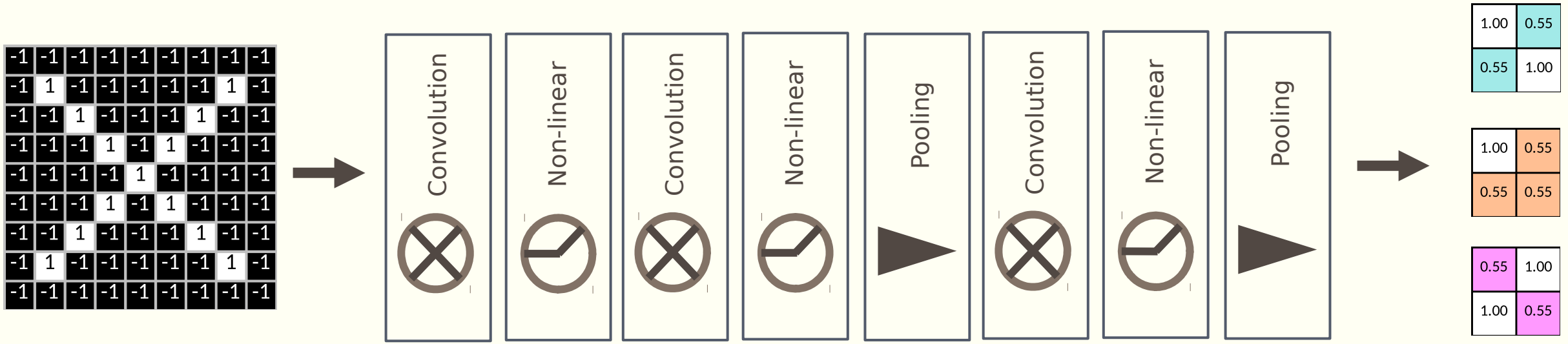
-1 -1 -1 -1 1 -1 -1 -1 -1
-1 -1 -1 1 -1 1 -1 -1 -1
-1 -1 1 -1 -1 -1 1 -1 -1
-1 1 -1 -1 -1 -1 -1 1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
Convolution
Non-linear
Pooling
1.00 0.33 0.55 0.33
0.33 1.00 0.33 0.55
0.55 0.33 1.00 0.11
0.33 0.55 0.11 0.77
0.55 0.33 0.55 0.33
0.33 1.00 0.55 0.11
0.55 0.55 0.55 0.11
0.33 0.11 0.11 0.33
0.33 0.55 1.00 0.77
0.55 0.55 1.00 0.33
1.00 1.00 0.11 0.55
0.77 0.33 0.55 0.33

Stacking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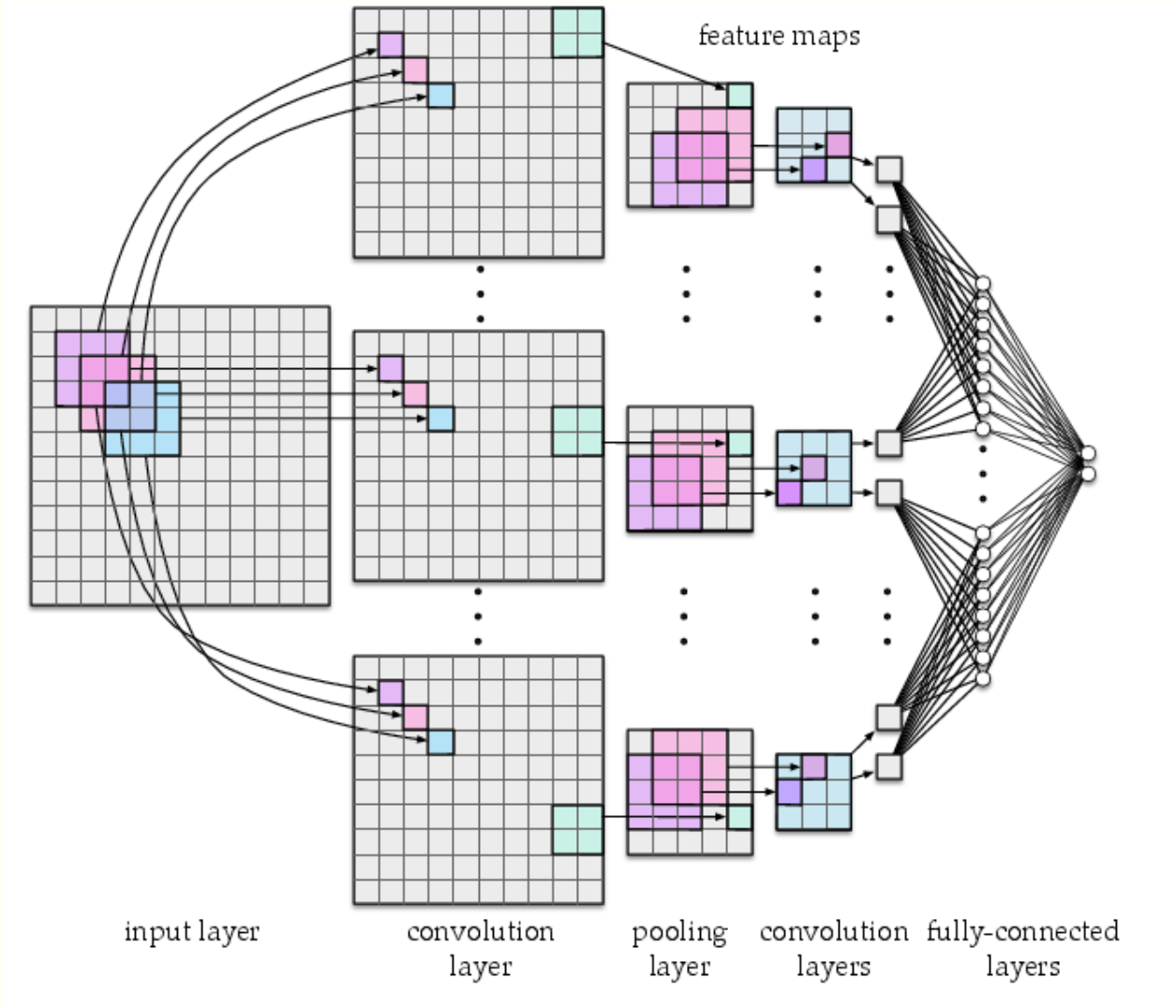
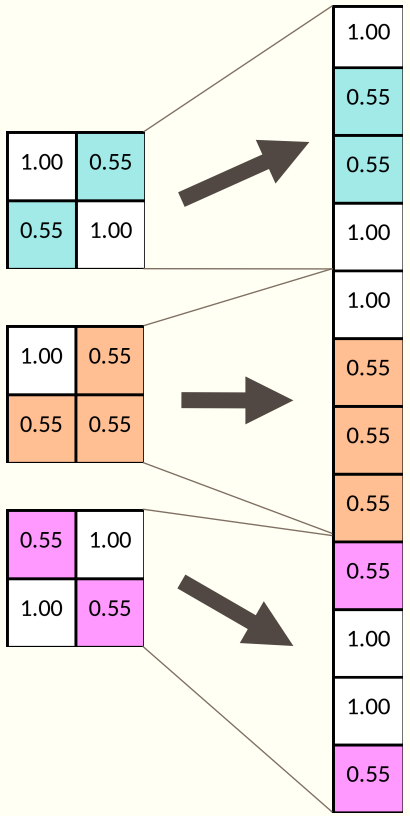
-1 -1 1 -1 -1 -1 1 -1 -1
-1 1 -1 -1 -1 -1 -1 1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
Convolution
Non-linear
Convolution
Non-linear
Pooling
Convolution
Non-linear
Pooling
1.00 0.55
0.55 1.00
1.00 0.55
0.55 0.55
0.55 1.00
1.00 0.55

Term: fully-connected layer

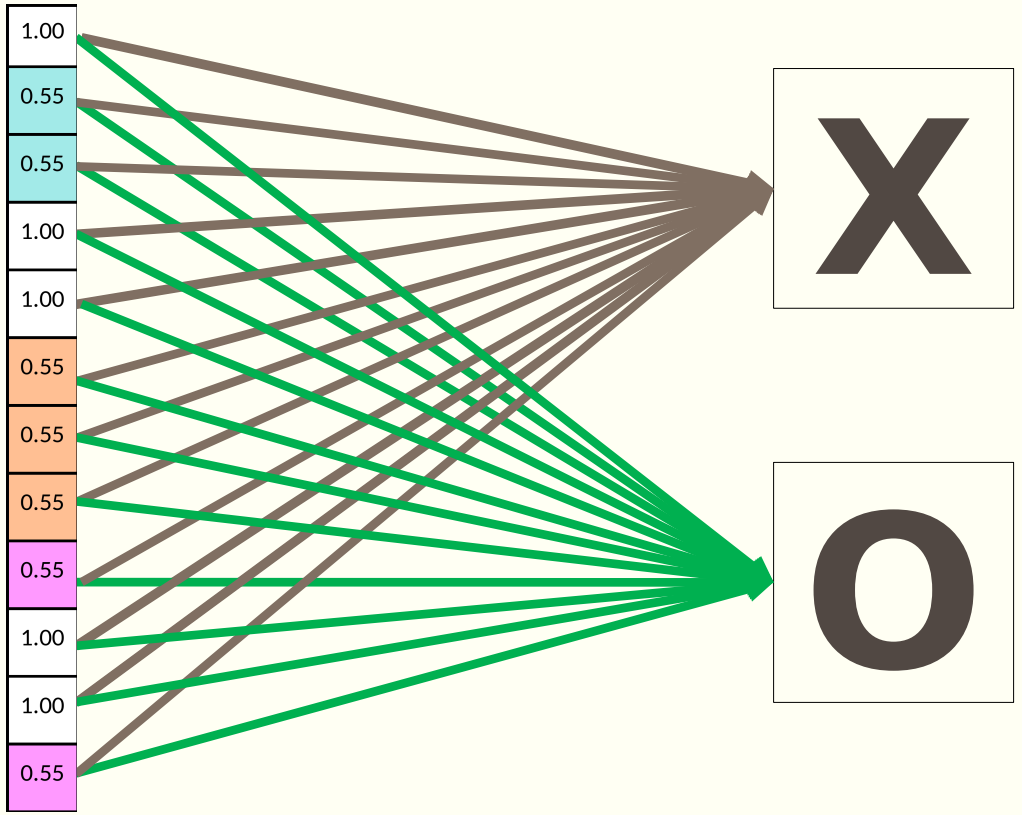
- takes an input volume and outputs an N dimensional vector



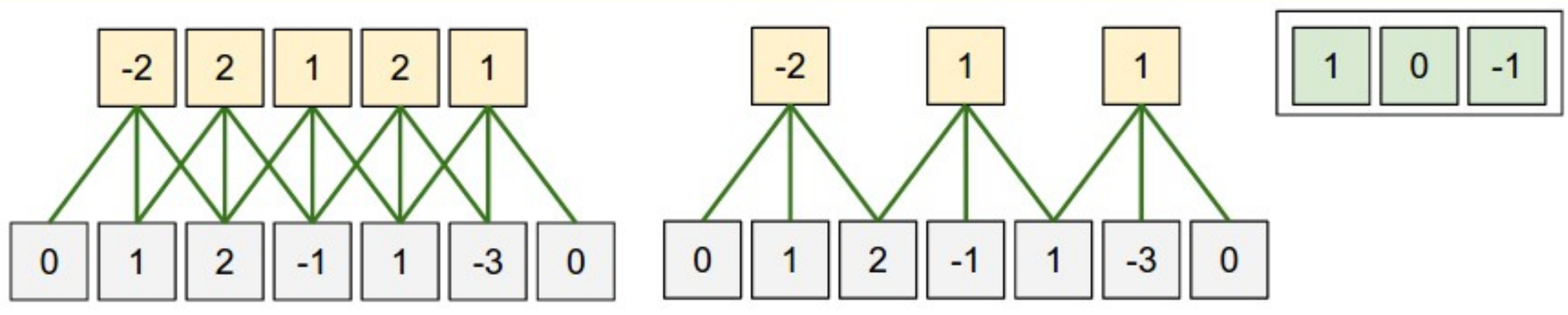
Toy example: fully-connected layer



fully-connected layer => Voting on an answer

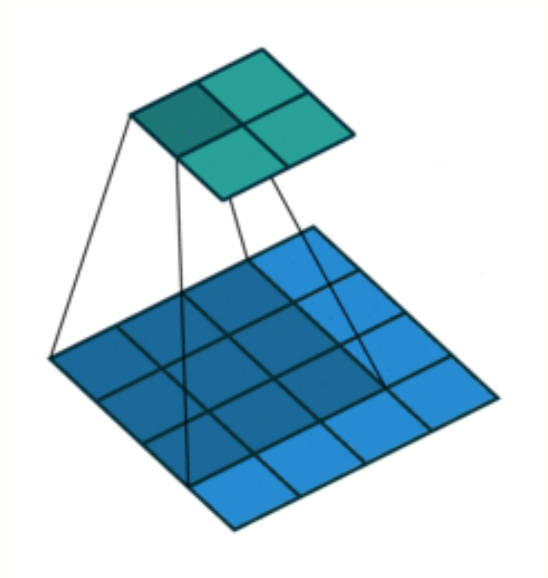


Term: Strides

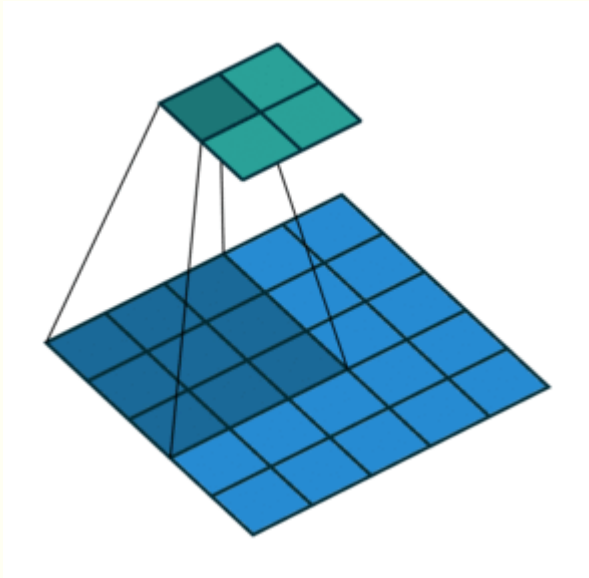


http://cs231n.github.io/convolutional-networks/

Term: Strides

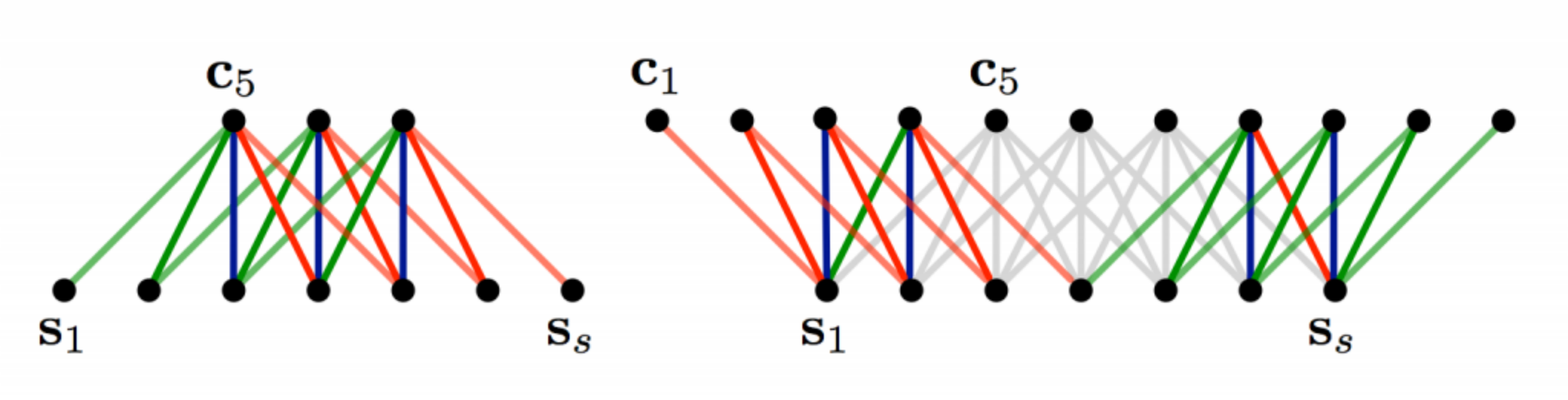


without strides



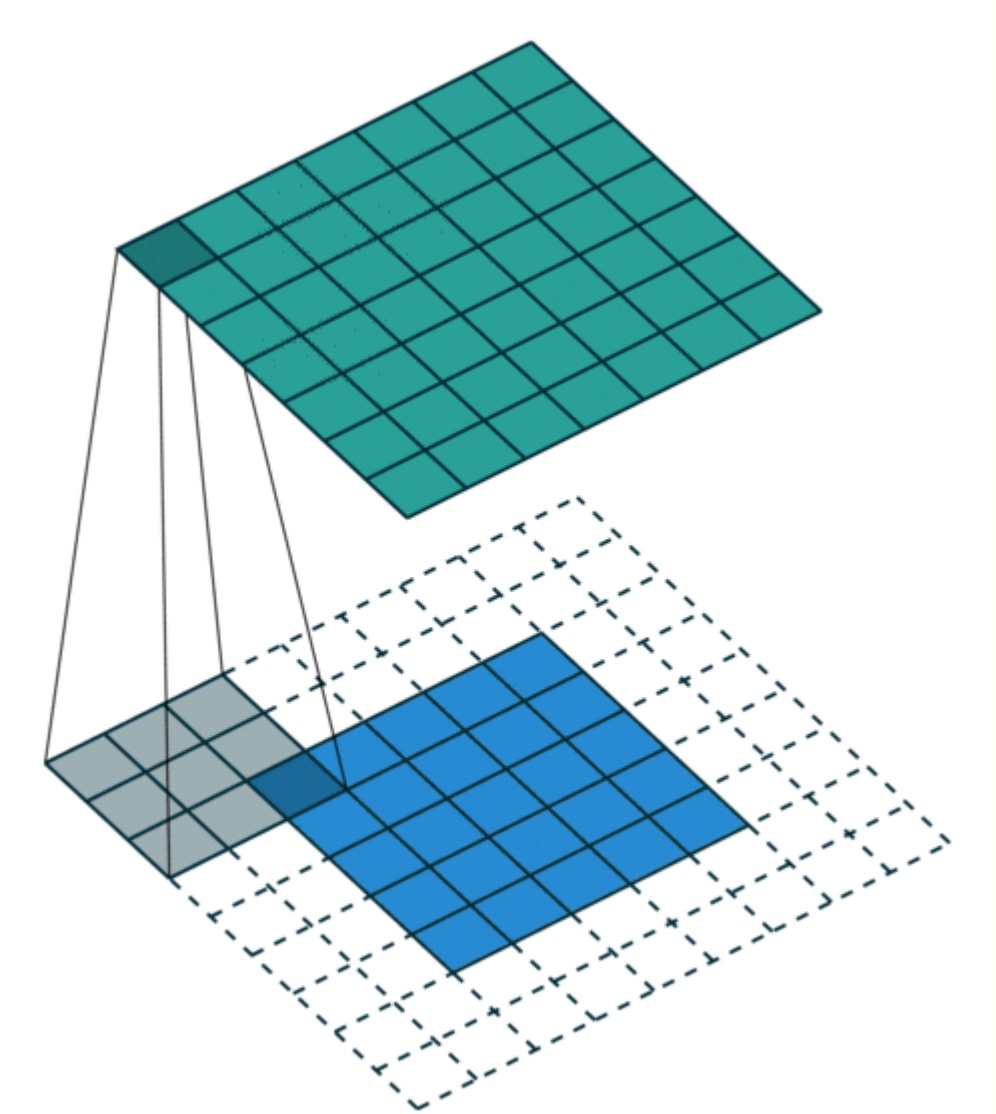
with strides

Term: Padding



A Convolutional Neural Network for Modelling Sentences (2014)

Term: Padding



NLP: What area would be good fits

classifications tasks, such as:

- Sentiment Analysis
- Spam Detection
- Topic Categorization

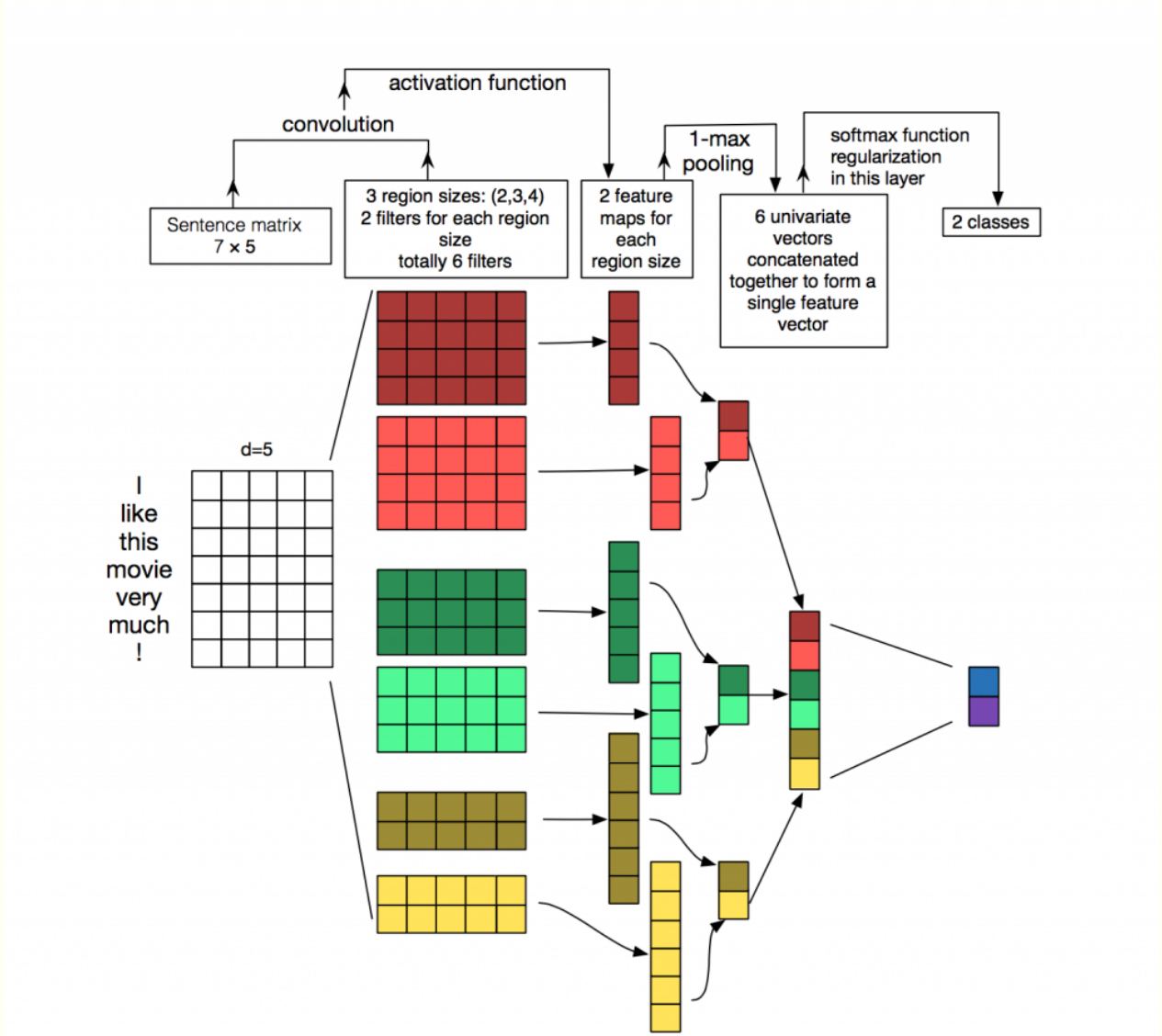
NLP: What area would be bad fits

Convolutions and pooling operations lose information about the local order of words

- PoS Tagging
- Entity Extraction

=> sequence tagging is a harder to fit into a pure CNN architecture

NLP



Source: Zhang, Y., & Wallace, B. (2015). A Sensitivity Analysis of (and Practitioners' Guide to) Convolutional Neural Networks for Sentence Classification

References

- [1] Kim, Y. (2014). Convolutional Neural Networks for Sentence Classification. Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP 2014), 1746–1751.
- [2] Kalchbrenner, N., Grefenstette, E., & Blunsom, P. (2014). A Convolutional Neural Network for Modelling Sentences. Acl, 655–665.
- [3] Santos, C. N. dos, & Gatti, M. (2014). Deep Convolutional Neural Networks for Sentiment Analysis of Short Texts. In COLING-2014 (pp. 69–78).
- [4] Johnson, R., & Zhang, T. (2015). Effective Use of Word Order for Text Categorization with Convolutional Neural Networks. To Appear : NAACL-2015, (2011).
- [5] Johnson, R., & Zhang, T. (2015). Semi-supervised Convolutional Neural Networks for Text Categorization via Region Embedding.
- [6] Wang, P., Xu, J., Xu, B., Liu, C., Zhang, H., Wang, F., & Hao, H. (2015). Semantic Clustering and Convolutional Neural Network for Short Text Categorization. Proceedings ACL 2015, 352–357.
- [7] Zhang, Y., & Wallace, B. (2015). A Sensitivity Analysis of (and Practitioners' Guide to) Convolutional Neural Networks for Sentence Classification,
- [8] Nguyen, T. H., & Grishman, R. (2015). Relation Extraction: Perspective from Convolutional Neural Networks. Workshop on Vector Modeling for NLP, 39–48.
- [9] Sun, Y., Lin, L., Tang, D., Yang, N., Ji, Z., & Wang, X. (2015). Modeling Mention , Context and Entity with Neural Networks for Entity Disambiguation, (Ijcai), 1333–1339.

References

- [10] Zeng, D., Liu, K., Lai, S., Zhou, G., & Zhao, J. (2014). Relation Classification via Convolutional Deep Neural Network. Coling , (2011), 2335–2344.
- [11] Gao, J., Pantel, P., Gamon, M., He, X., & Deng, L. (2014). Modeling Interestingness with Deep Neural Networks.
- [12] Shen, Y., He, X., Gao, J., Deng, L., & Mesnil, G. (2014). A Latent Semantic Model with Convolutional-Pooling Structure for Information Retrieval . Proceedings of the 23rd ACM International Conference on Conference on Information and Knowledge Management – CIKM ’14, 101–110.
- [13] Weston, J., & Adams, K. (2014). # T AG S PACE : Semantic Embeddings from Hashtags, 1822–1827.
- [14] Brandon Roher, Toy example
- [15] Santos, C., & Zadrozny, B. (2014). Learning Character-level Representations for Part-of-Speech Tagging. Proceedings of the 31st International Conference on Machine Learning, ICML-14(2011), 1818–1826.
- [16] Zhang, X., Zhao, J., & LeCun, Y. (2015). Character-level Convolutional Networks for Text Classification, 1–9.
- [17] Zhang, X., & LeCun, Y. (2015). Text Understanding from Scratch. arXiv E-Prints, 3, 011102.
- [18] Kim, Y., Jernite, Y., Sontag, D., & Rush, A. M. (2015). Character-Aware Neural Language Models.