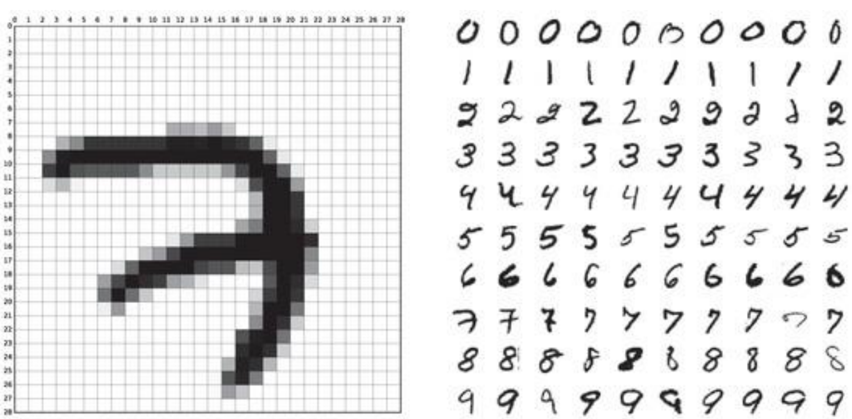
Application of the Lottery Ticket Hypothesis in NLP and Early Pruning

Intermission



(a) MNIST sample belonging to the digit '7'. (b) 100 samples from the MNIST training set.

Source: https://www.mdpi.com/applsci/applsci-09-03169/article_deploy/html/images/applsci-09-03169-g001-550.jpg

Source: https://www.bonaccorso.eu/wp-content/uploads/2016/07/28019400581_e1eb13ccc8_b.jpg

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15-Nov-19

Structure

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Related Work

Task Definition

Progress

Remaining Work

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Content of the thesis

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Context of Deep Learning

- Good reasons to initialize & train neural networks with many parameters

- Most networks can be reduced after training while maintaining performance
  - "Pruning"

Introduction – Lottery Tickets

Context of Deep Learning

- Good reasons to initialize & train neural networks with many parameters
- Most networks can be reduced after training while maintaining performance
  - "Pruning"
- Main Question:
  - "How important are the pruned weights during training?"

Introduction – Lottery Tickets

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Hypothesis

- Sheer number of subnetworks results in subnetworks with favorable initialization

Introduction – Lottery Tickets

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Hypothesis

- Sheer number of subnetworks results in subnetworks with favorable initialization
- Extraction of "lottery-ticket" after the full network is trained
  - Pruning weights based on magnitude finds a lottery ticket

Introduction – Lottery Tickets

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Hypothesis

- Sheer number of subnetworks results in subnetworks with favorable initialization
- Extraction of "lottery-ticket" after the full network is trained
  - Pruning weights based on magnitude finds a lottery ticket
- Train a subnetwork with initial parameters
  - Similar performance ==> "lottery ticket"

Motivation

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Time & Memory

- Speedup during execution just as regular pruning
  - But remarkable compression rate: up to ~50x
- Decrease in memory usage during execution
- Possible speedup during development
  - There might be a way to identify lottery tickets early

Motivation

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Time & Memory

- Speedup during execution just as regular pruning
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Theory of Neural Networks

- "Lottery-tickets" contain weights necessary for training
- Identification of "lottery-tickets" might explain importance of weights

Related Work

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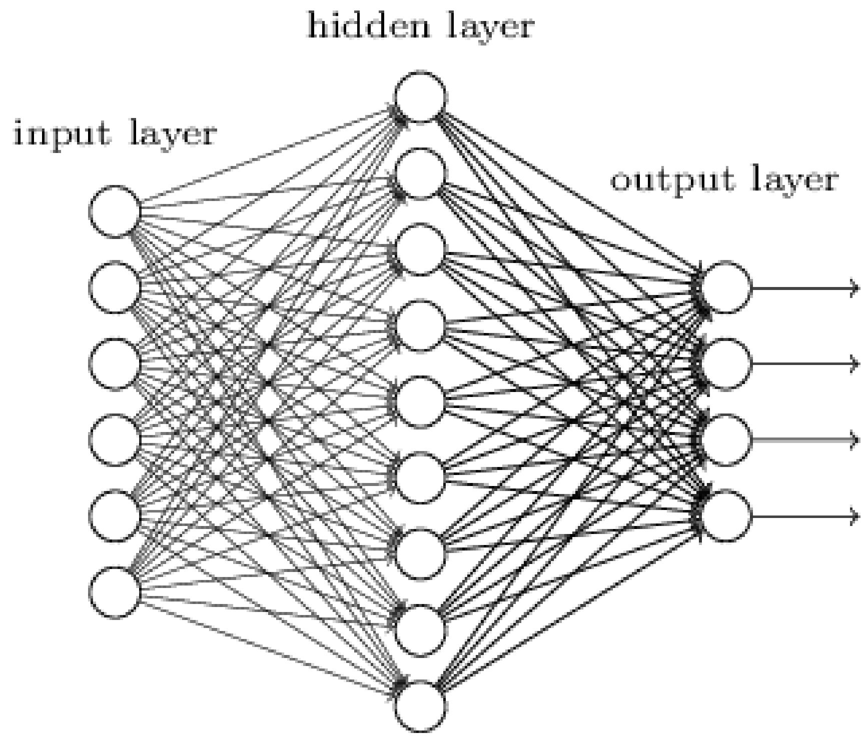
Fully Connected Neural Network



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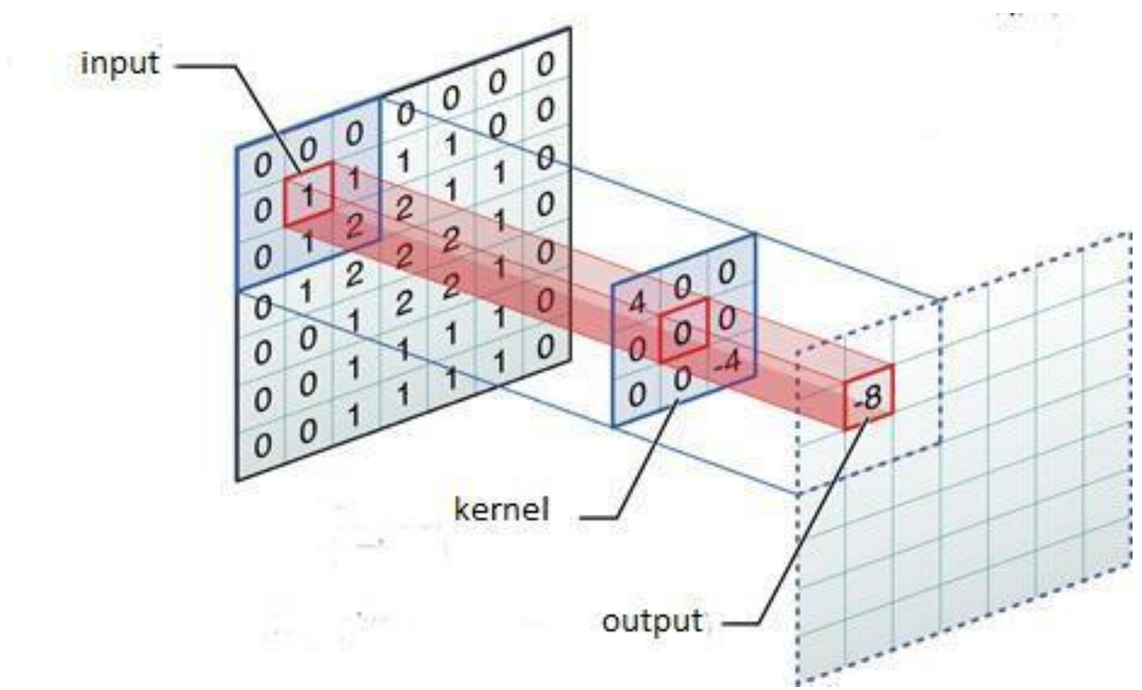
Convolution in Neural Networks



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Related Work – Background

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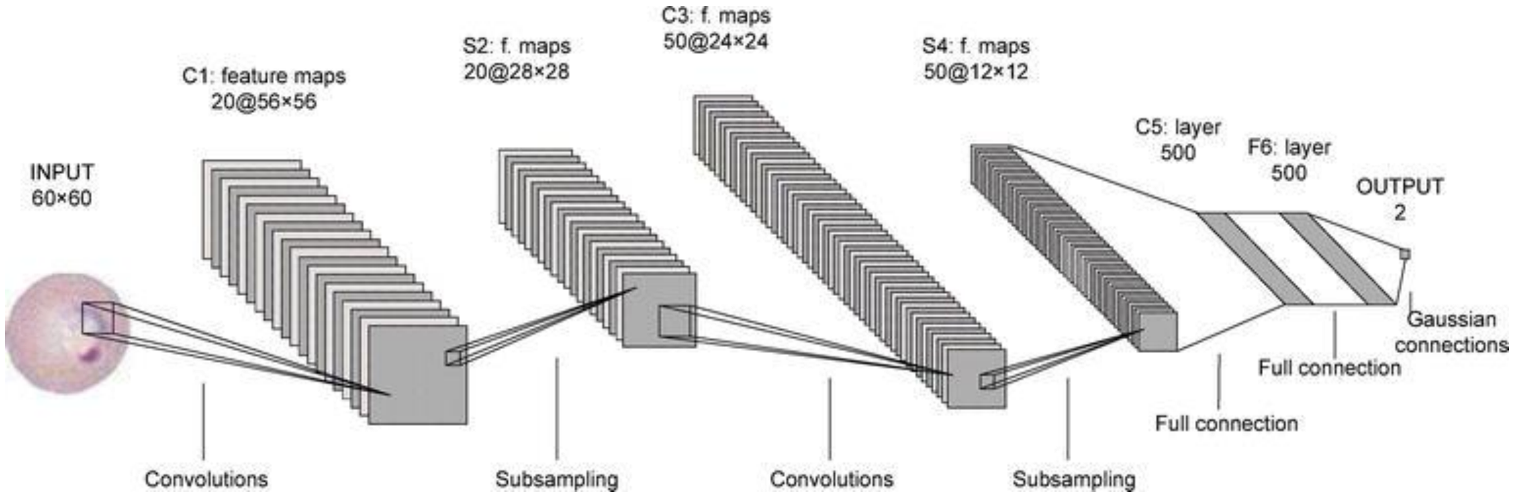
Convolutional Neural Network Architecture (Lenet-5)



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Related Work – Background

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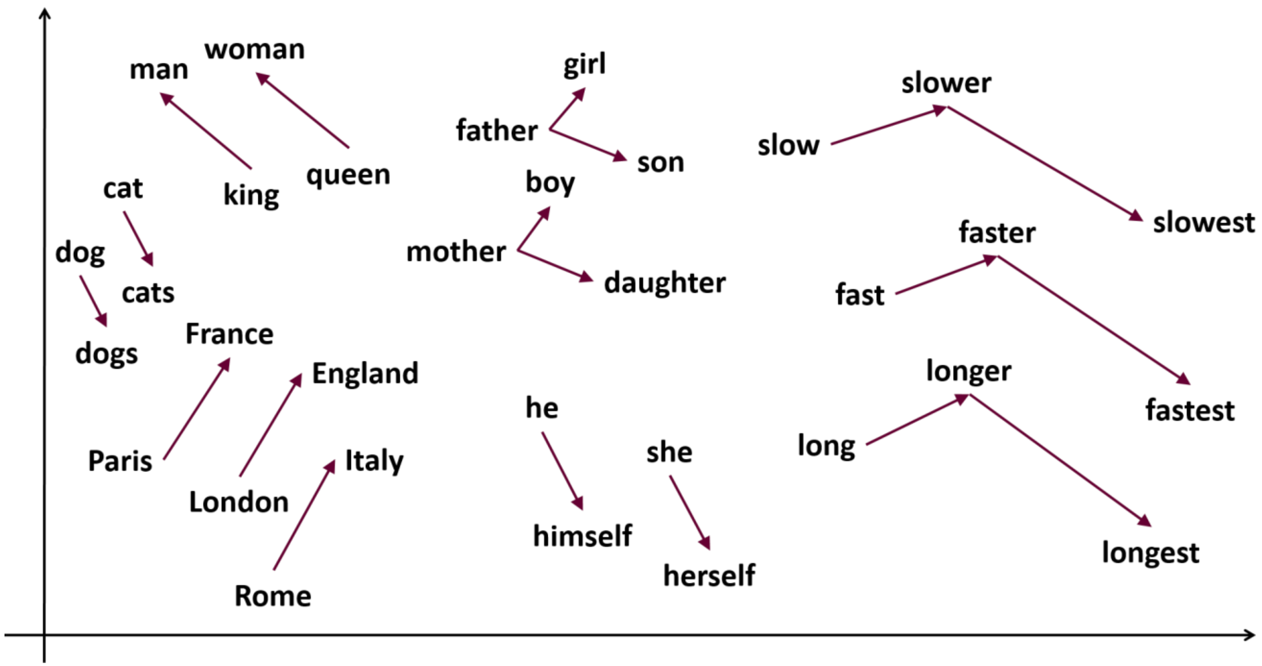
Language Models



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Related Work – Background

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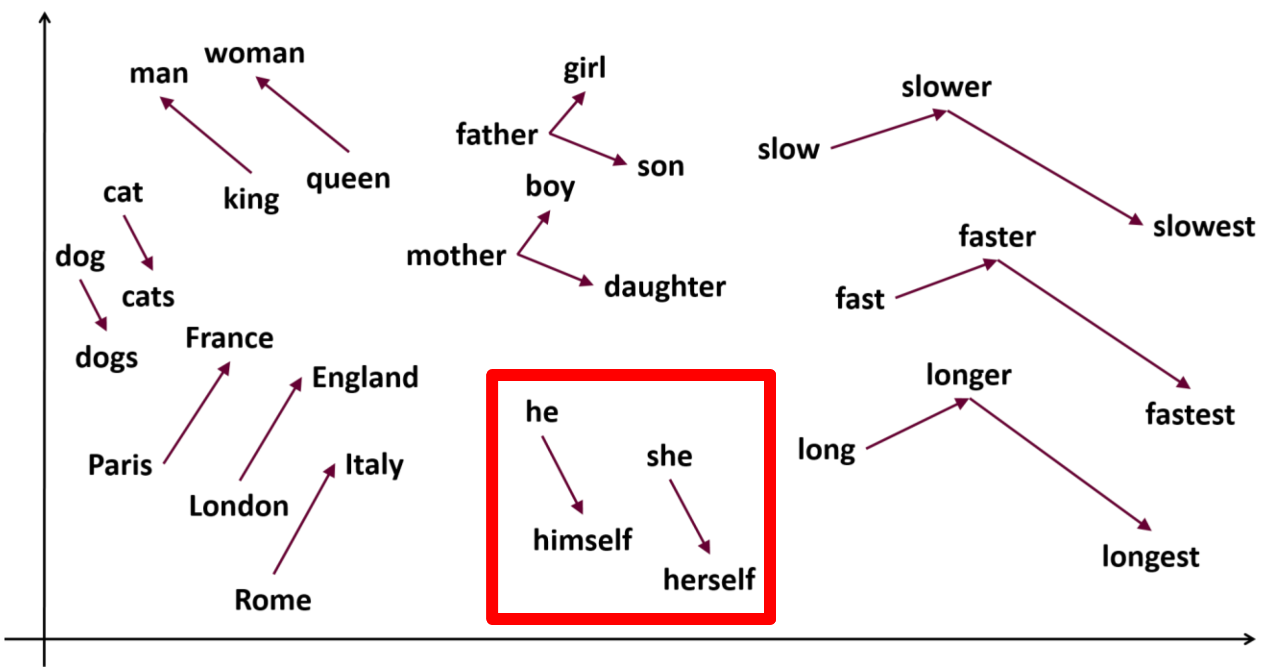
Language Models



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Related Work – CNN in NLP

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"Convolutional Neural Networks for Sentence Classification"

- 2014
- Task:
  - Varying Classifications
- Datasets:
  - Movie reviews
  - SST-1, SST-2
  - Subjectivity dataset
  - TREC question dataset
  - Customer reviews
  - MPQA

Related Work – CNN in NLP

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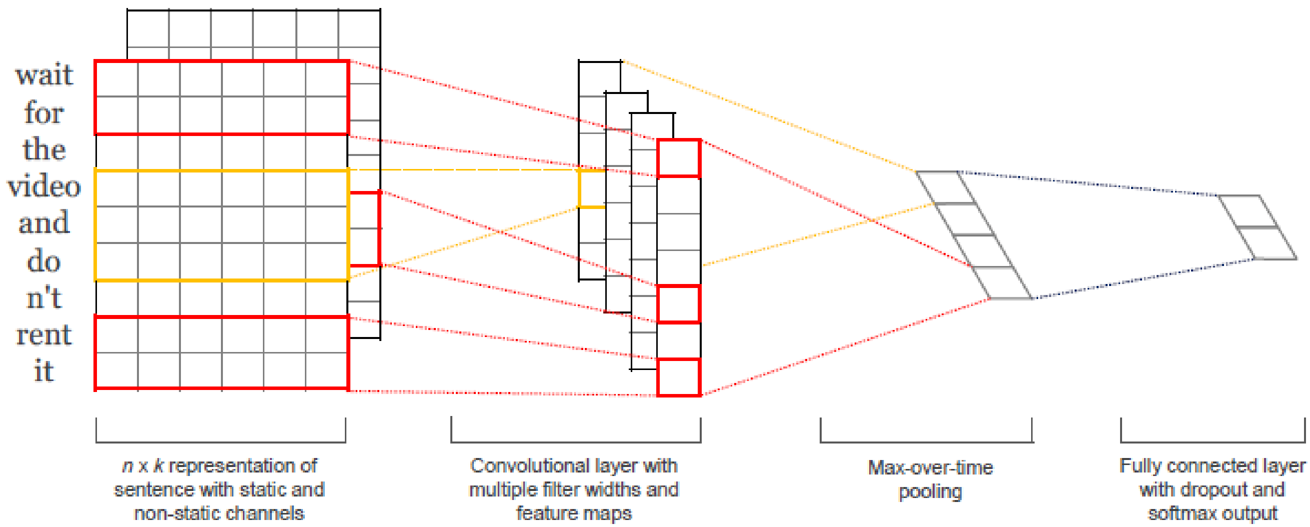
"Convolutional Neural Networks for Sentence Classification"



Source:
"Convolutional Neural Networks for Sentence Classification"
Figure 1

Related Work – Background

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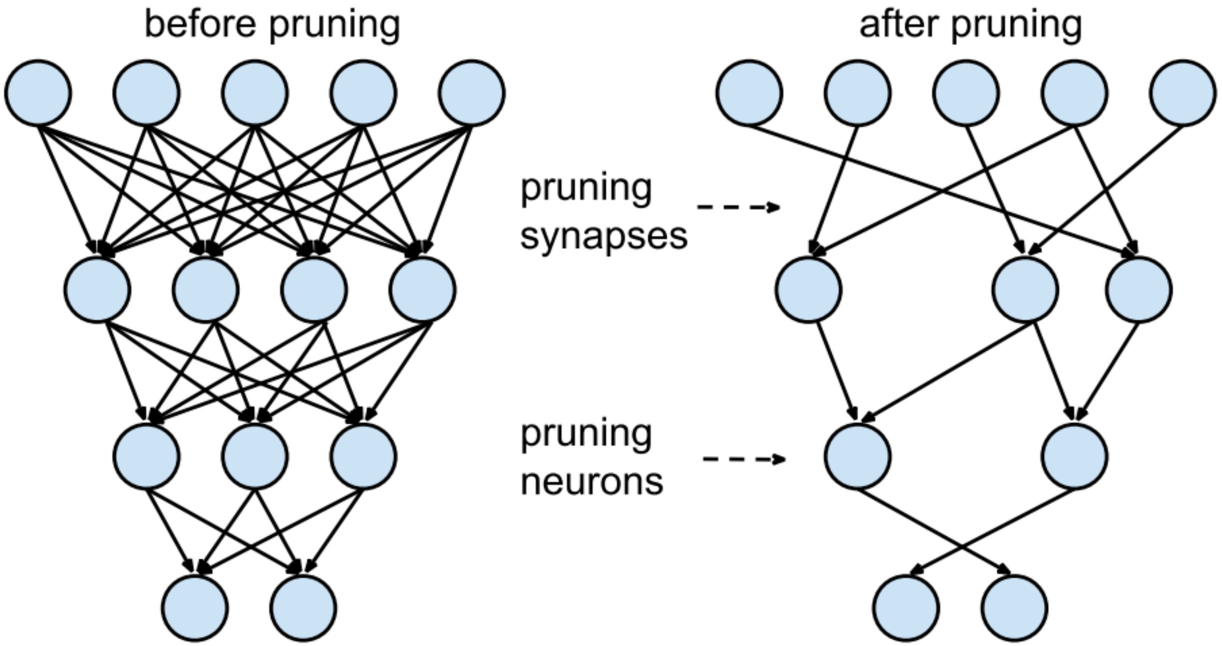

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"Learning both Weights and Connections for Efficient Neural Networks"
Figure.3

Related Work – Pruning

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"Learning both Weights and Connections for efficient Neural Networks"

- 2015 | Song Han et. al.
- Task:
  - Image Classification (ImageNet)
- Architectures:
  - LeNet (300-100-FC, 5-CNN)
  - AlexNet
  - VGG-16
- Compression:
  - 9x to 13x

Related Work – Pruning

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"ThiNet: A Filter Level Pruning Method for Deep Neural Network Compression"

- 2017 | Jian-Hao Luo et. al.

- Task:
  - Image Classification (ImageNet)

- Architectures:
  - VGG-16
  - ResNet-50

- Compression:
  - Up to ~17x

Related Work – Pruning

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"The Lottery Ticket Hypothesis: Finding Sparse, Trainable Neural Networks"

- 2019 | J. Frankle & M. Carbin
- Task:
  - Image Classification (MNIST)
- Architectures:
  - Lenet-FCN (300-100-FCN)
  - Simple CNN (Conv-2, Conv-4, Conv-6)
  - VGG-19
  - ResNet-18
- Compression: ~20x to ~50x

Related Work – Early Pruning

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"Really should we pruning after model be totally trained? Pruning based on a small amount of training"

- 2019 | Yue Li et. Al.
- Task:
  - Image Classification (MNIST, CIFAR-10)
- Architectures:
  - Unspecified CNN
  - VGG-19
- Compression --- Training Speed-Up:
  - ~10x --- 10x

Related Work – Network Architecture Search

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Related Work – Network Architecture Search

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"Rethinking the Value of Network Pruning"

- 2018 | Anonymous Author

- **Observations**:
  - Randomizing weights does not worsen a pruned network
  - Weights are not essential to the quality of pruned network
  - Pruning at its core is about finding suitable network architectures

Related Work – Network Architecture Search

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"Network Architecture Search: A Survey"

- 2019 | Thomas Elsken et. al.

- **Categorization of NAS-Algorithms:**
  - Search Space:
    - Space of possible architectures
  - Search Strategy:
    - Policy while traversing the space
  - Performance Estimation Strategy:
    - Without knowledge of the "full" network

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Rem

"Deconstructing Lottery Tickets: Zeros, Signs, and the Supermask"

- 2019 | Hattie Zhou et. al.

- Alteration of the Search Strategy (based on Magnitude):
  - large final (original strategy)
  - small final
  - large initial
  - small initial
  - large init & large final
  - small initial & small final
  - magnitude increase
  - movement
  - random (baseline strategy)

Related Work – Network Architecture Search

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Related Work – Network Architecture Search

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- 2019 | Hattie Zhou et. al.

- Alteration of the Search Strategy (based on Magnitude):
  - large final (original strategy) → large final & same sign
  - small final
  - large initial
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  - large init & large final
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  - movement
  - random (baseline strategy)

Structure

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Task I

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Reproduction

- No source-code available
  - ➡ Produce own source-code
- Verify source-code by running experiments from the paper
  - Lenet-FCN
  - CNN-4
  - VGG-18

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Transfer to NLP

- Original context for the paper
  - Task: Image Classification
  - Dataset: "MNIST"
  - Model: Varying FCN and CNN
- Find comparable context in NLP
  - Task: Topic Classification
  - Dataset: "Reuters-21578"
  - Model: TBD
- Check if the Lottery-Ticket-Hypothesis holds

Task III

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Early Retrieval of Lottery Tickets

- Original method
  - Keep all weights with large final weights
  - Reset weights to original initial value
  - Retrain network
  - Repeat (Optional)

- Adaptation
  - "Select" weights earlier ~ develop early stopping criteria
  - Keep weights based on other metrics (Optional)

Progress – Python-project

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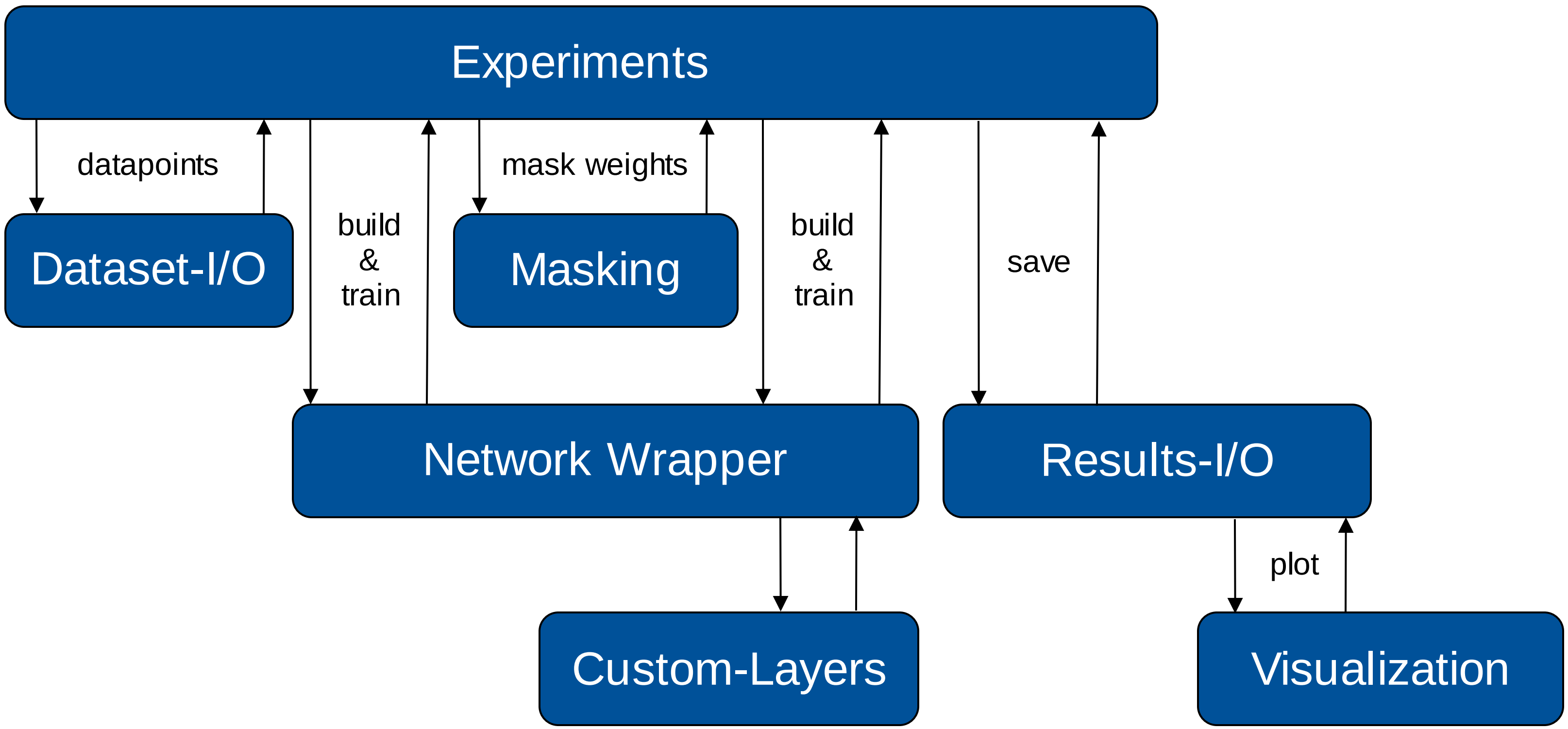
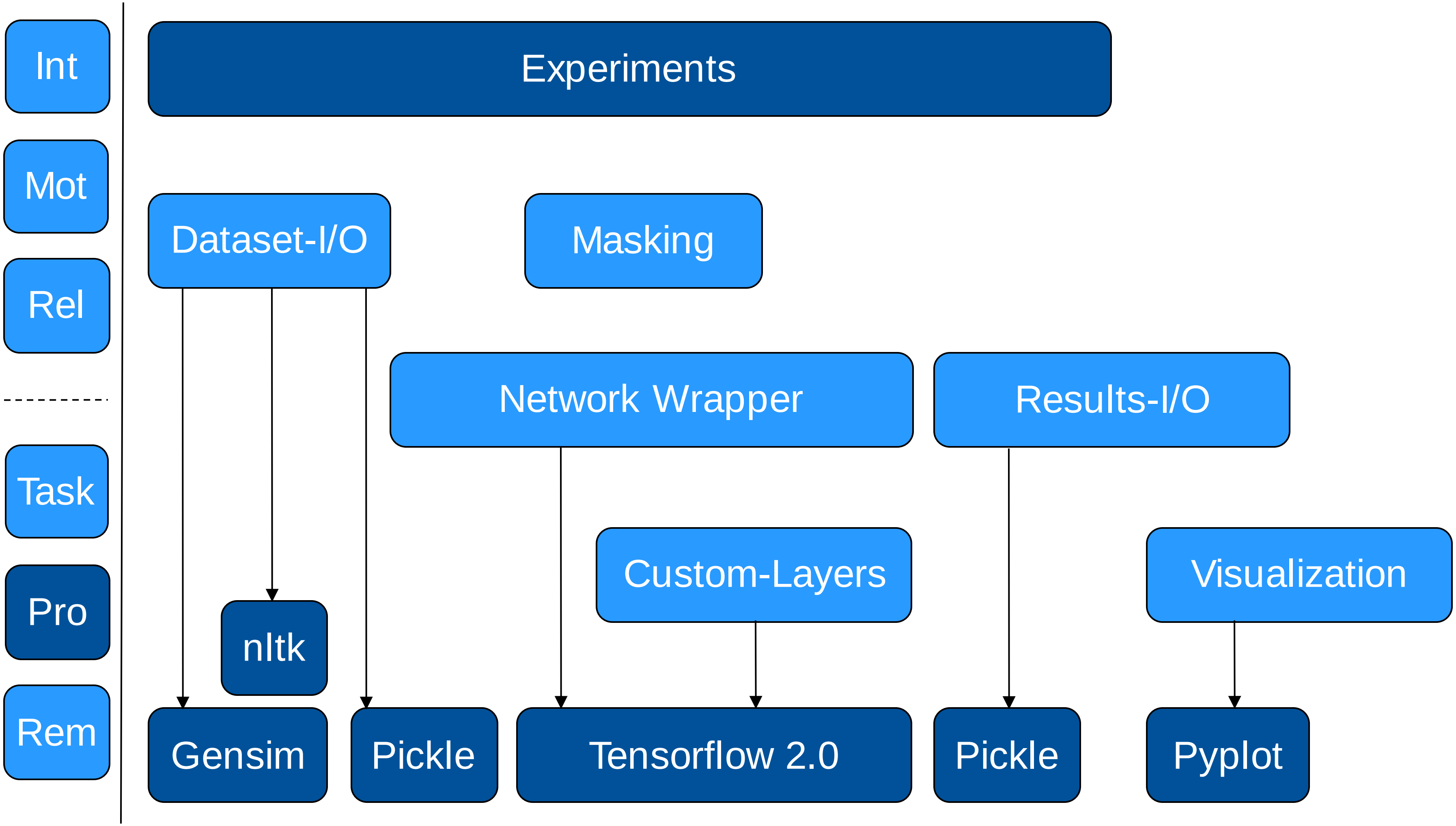


Progress – Backend



Progress – Experiments

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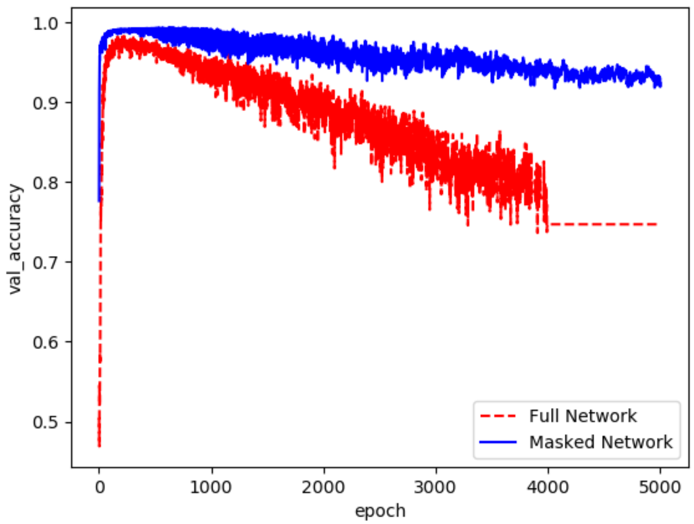
Lenet-FCN-MNIST

- Validation-Accuracy
  - 20% pruned weights



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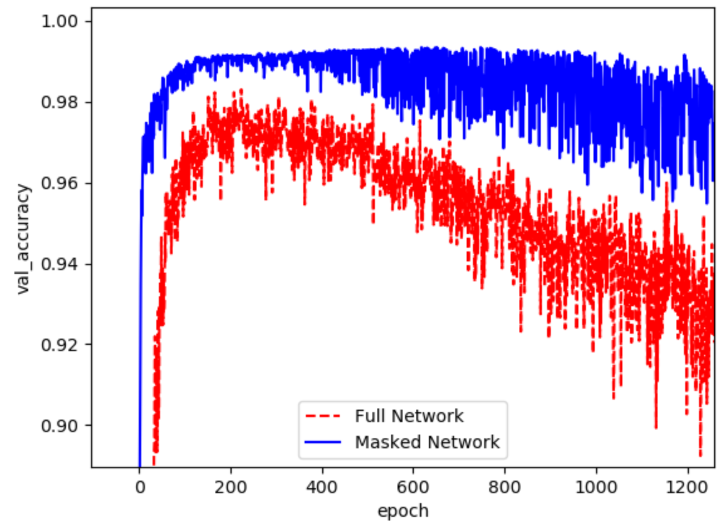
Produced by the author



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Progress – Experiments

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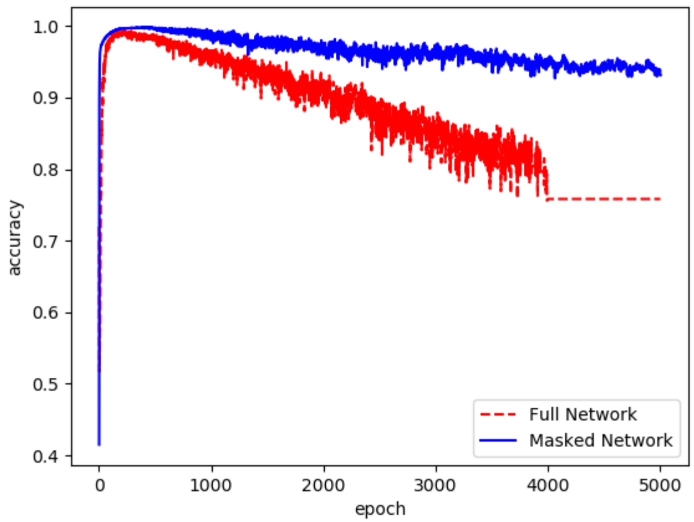
Lenet-FCN-MNIST

- Training-Accuracy



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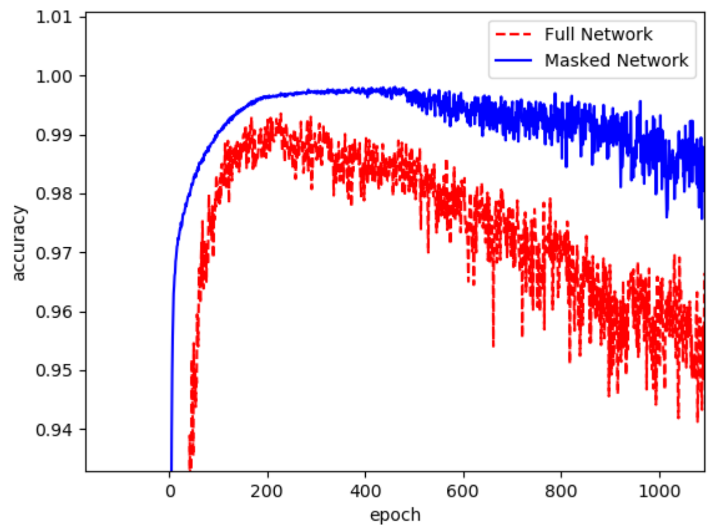

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Progress – Background

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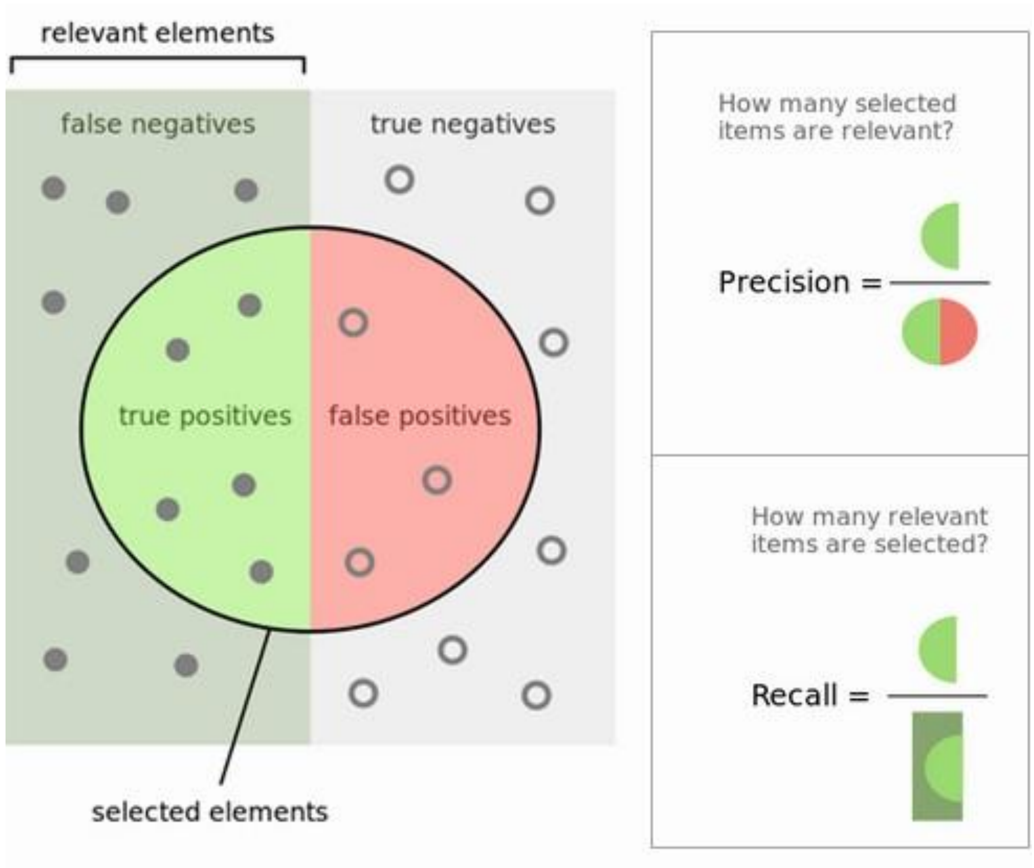

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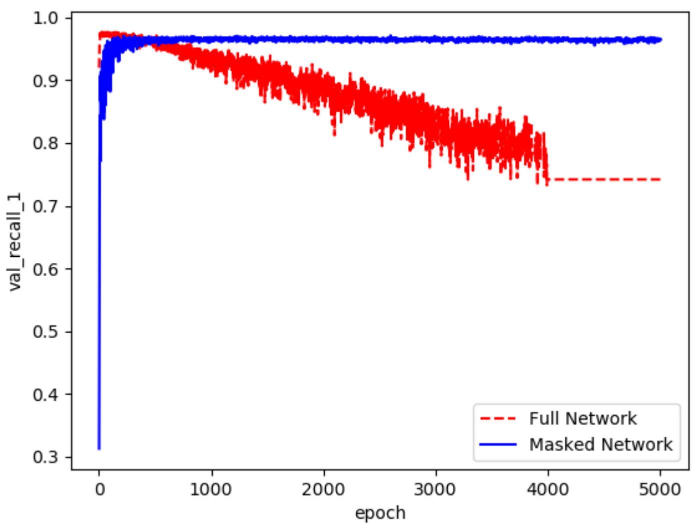
https://www.kdnuggets.com/images/precision-recall-relevant-selected.jpg

Progress – Experiments

Lenet-FCN-MNIST

- Validation-Recall



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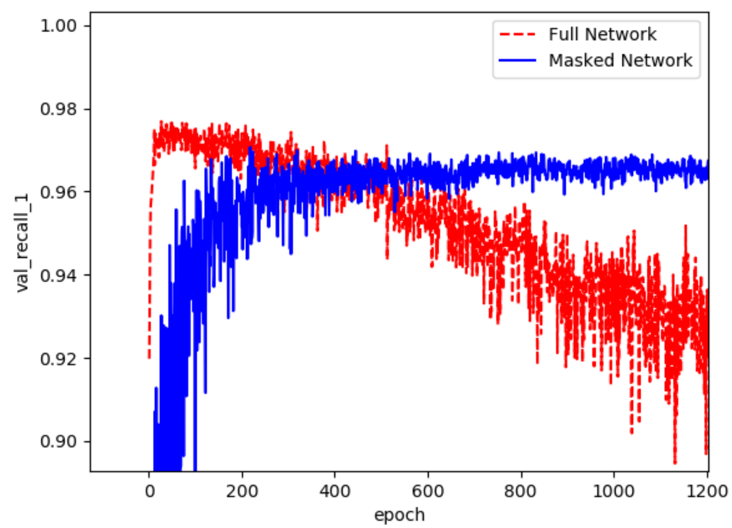

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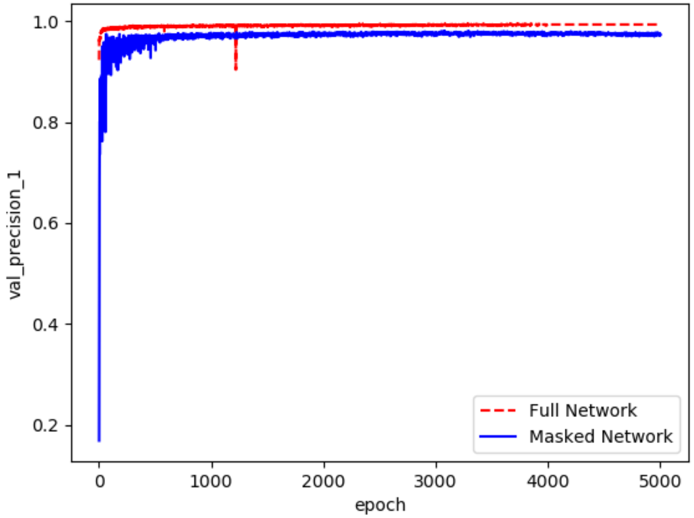
Lenet-FCN-MNIST

- Validation-Precision



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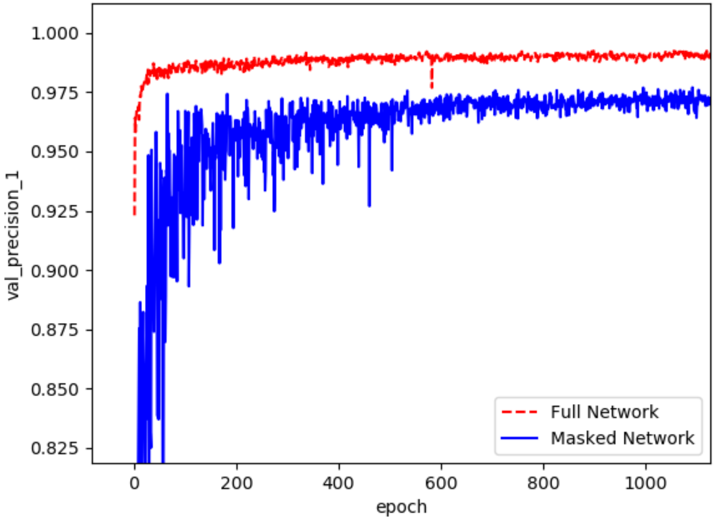

Source:
Produced by the author

Remaining Work

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Remaining parts of the framework

- Custom Convolutional Layer
- Support for iterative Pruning

More experiments

- MNIST / CNN-4
- MNIST / VGG-18
- Reuters / TBD
- MNIST / Lenet-FCN / Early Pruning

Thank you for your attention! Questions?