On the Random Subset Sum Problem and Neural Networks

COATI

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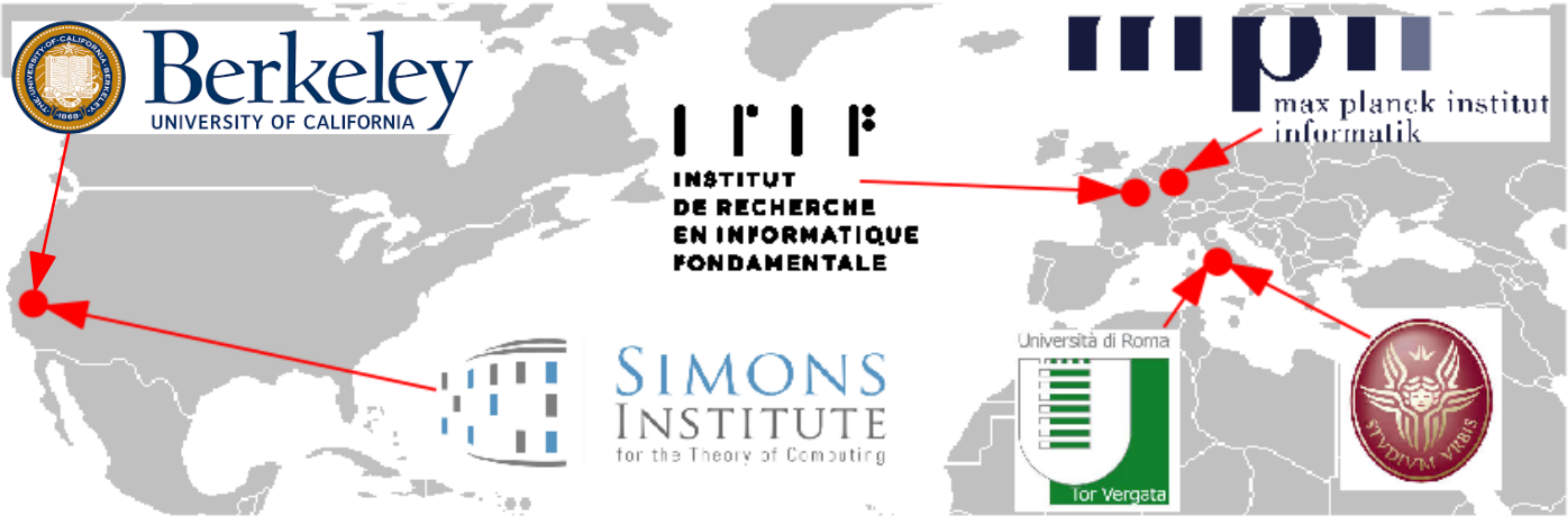
Supported by

DGA

Academic Path

- 2017 - PhD in CS, Sapienza University
- 2014/15 - IRIF, Paris
- 2016, 2018 - Simons Institute for the Theory of Computing
- 2017-2018 - Max-Planck Institute for Informatics
- 2019 - COATI, INRIA d'Université Côte d'Azur



Research Interests

Computational Dynamics

Best PhD + Young Reserscher Prizes by It. Ch. EATCS

2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

stochastic multiagent systems

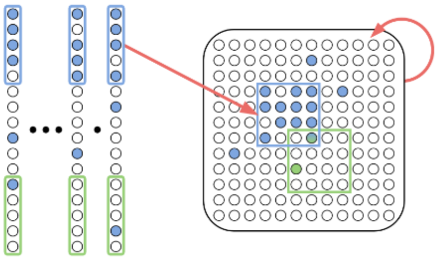
biological distributed algorithms

computational neuroscience

machine learning

IAMs

Assembly Calculus



Collaboration with

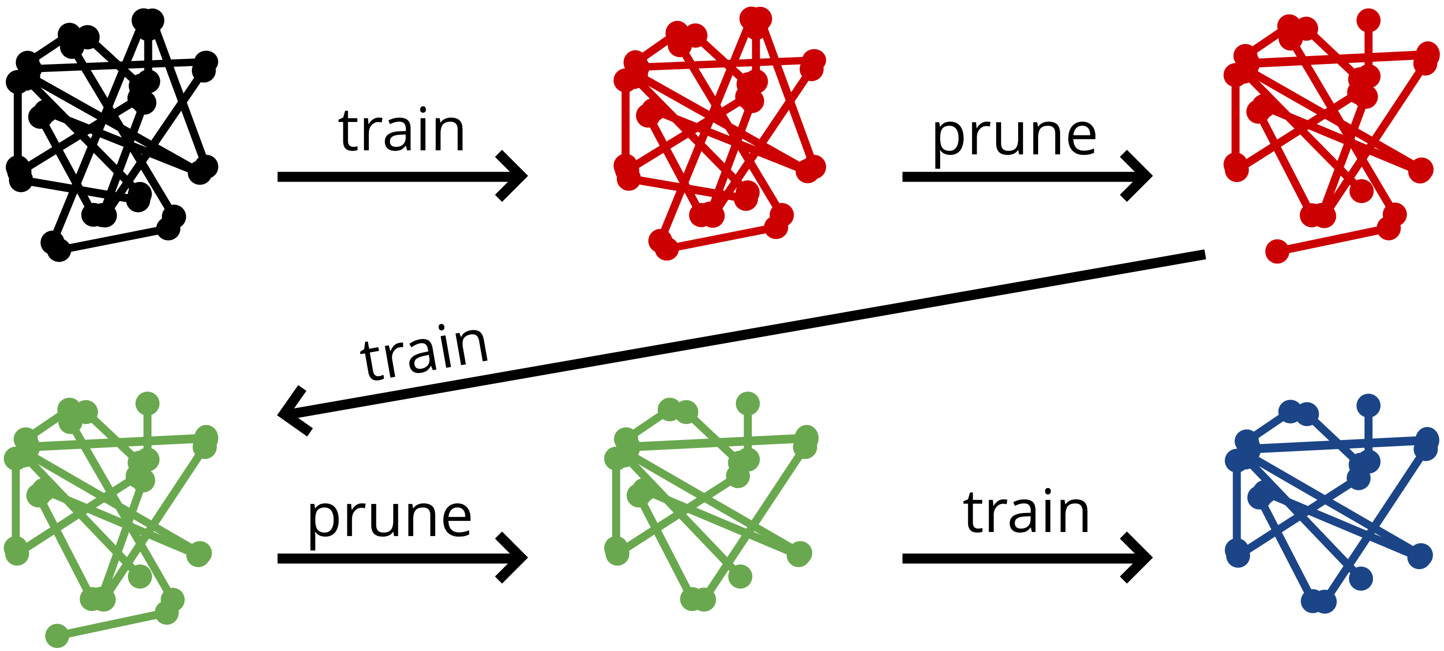
Athena
/CRONOS

" *Ideas are sculpted in the brain by sparsifying it.*

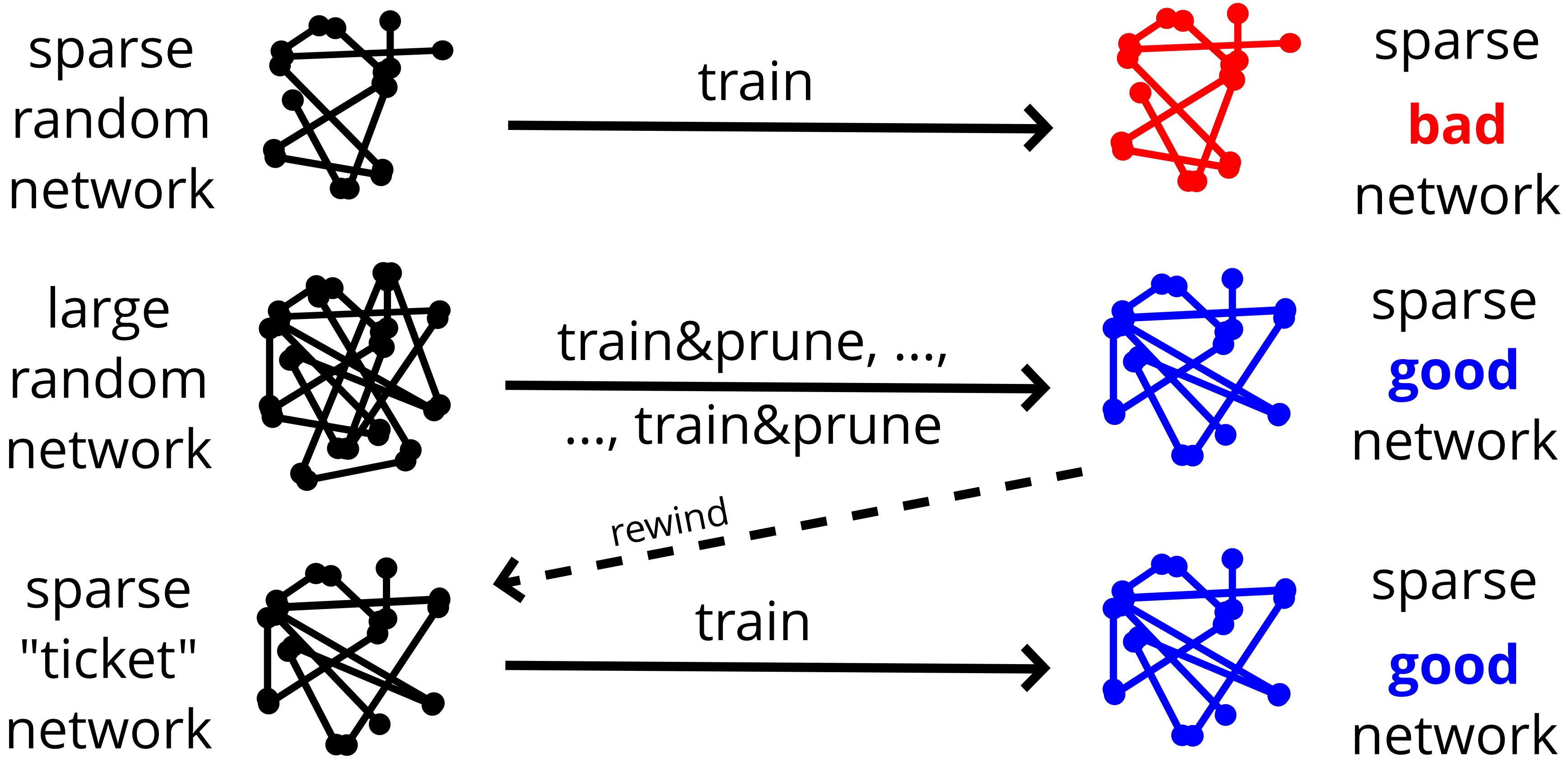
- L. Valiant

Neural Network Pruning

Blalock et al. (2020): **iterated magnitude pruning** still SOTA compression technique.



The Lottery Ticket Hypothesis



Frankle & Carbin (ICLR 2019):

Large random networks contains sub-networks that reach comparable accuracy when trained

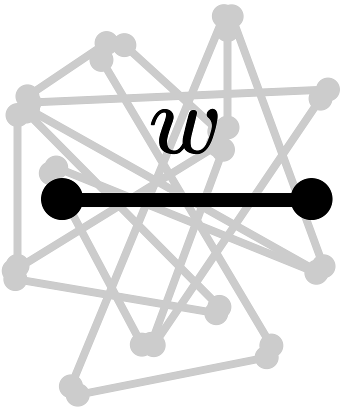
The **Strong** LTH

Ramanujan et al. (CVPR 2020) find a good subnetwork without changing weights (*train by pruning*!)

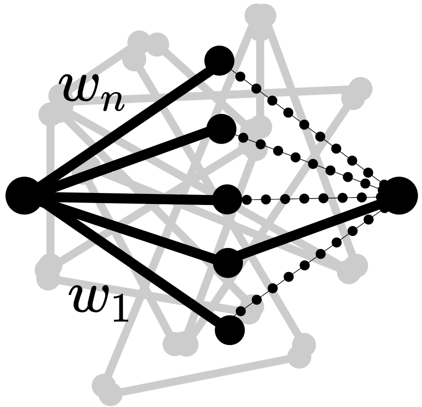
A network with random weights contains sub-networks that can approximate **any** given sufficiently-smaller neural network (without training)

Proving the SLTH

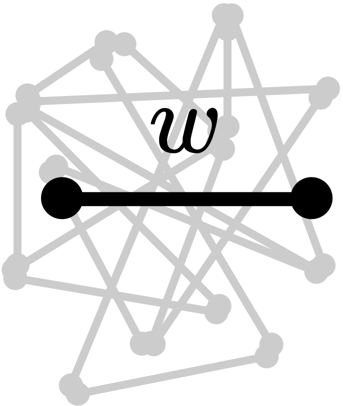
Malach et al. (ICML 2020)



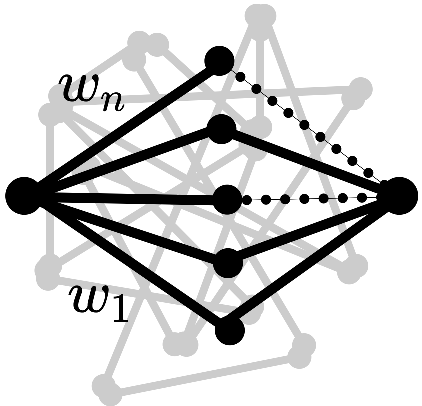
Find random weight close to w



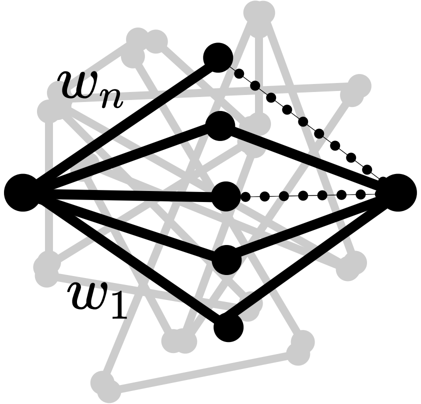
Pensia et al. (NeurIPS 2020)



Find combination of random weights close to w



SLTH and the Random Subset-Sum Problem



Find combination of random weights close to w:

$$\sum_{i \in S \subseteq \{1,\ldots,n\}} w_i \approx w$$

RSSP. For which n does the following holds?

Given $X_1, \ldots, X_n$ i.i.d. random variables, with prob. $1 - \epsilon$ for each $z \in [-1, 1]$ there is $S \subseteq \{1, \ldots, n\}$ such that

$$z - \epsilon \leq \sum_{i \in S} X_i \leq z + \epsilon.$$

Deep connection with integer linear programs

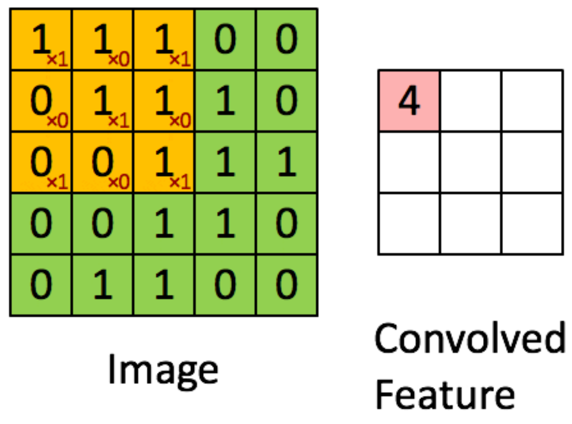
[Dyer & Frieze '89, Borst et al. '22]

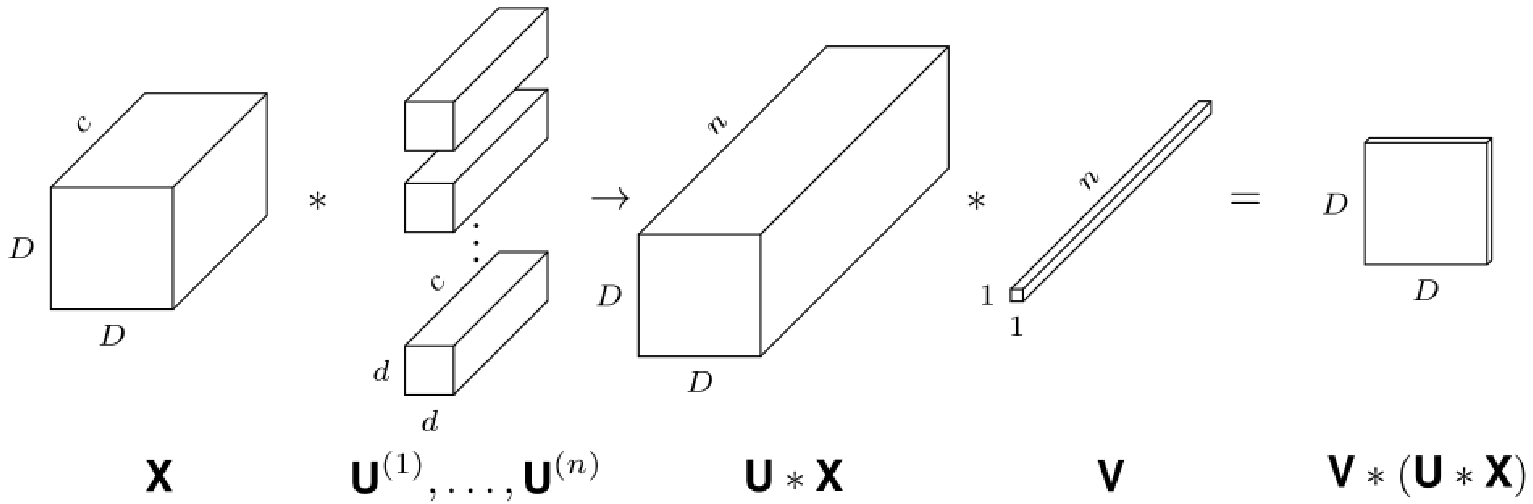
$\boxed{\text{Lueker '98: } n = O(\log \frac{1}{\epsilon})}$

SLTH for Convolutional Neural Networks

Theorem (da Cunha et al., ICLR 2022).

Given $\epsilon, \delta > 0$, any CNN with k parameters and ℓ layers, and kernels with ℓ_1 norm at most 1, can be approximated within error ϵ by pruning a random CNN with $O\left(k \log \frac{k\ell}{\min\{\epsilon,\delta\}}\right)$ parameters and 2ℓ layers with probability at least $1 - \delta$.





Thank you