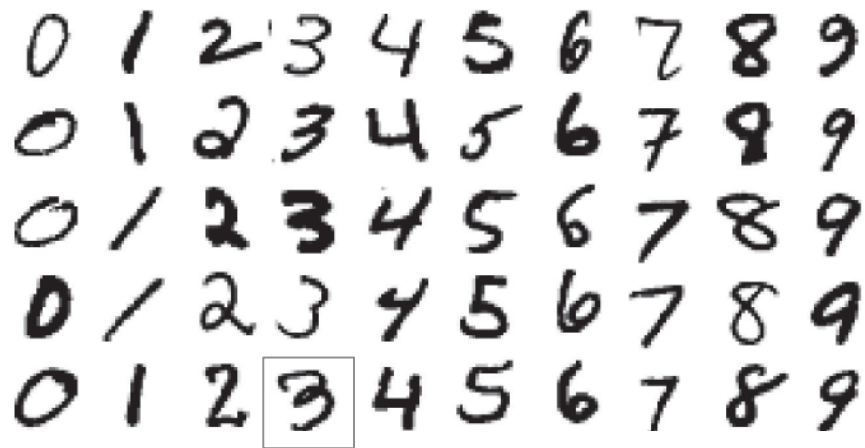
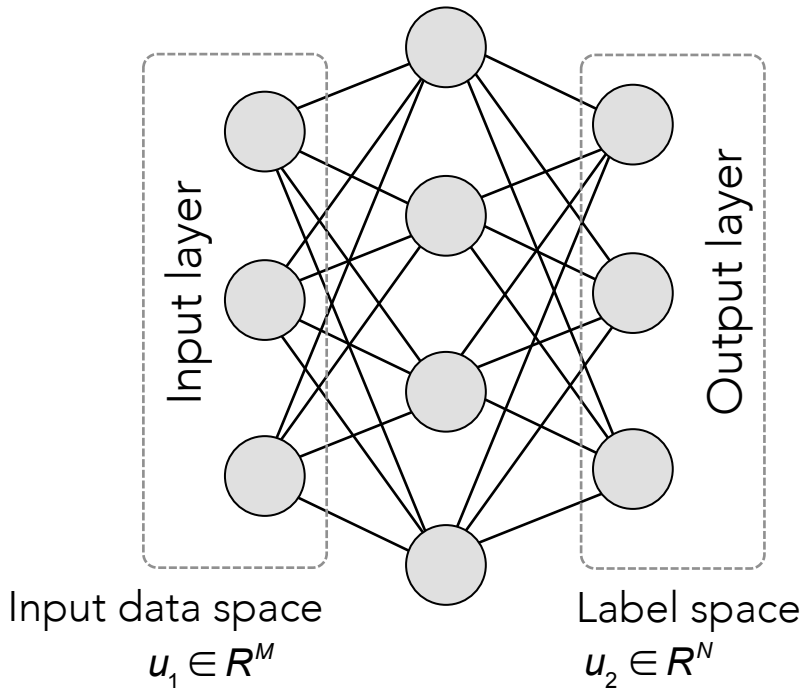


Machine learning powered by non-volatile memory: greedy edge-wise training

Doo Seok Jeong

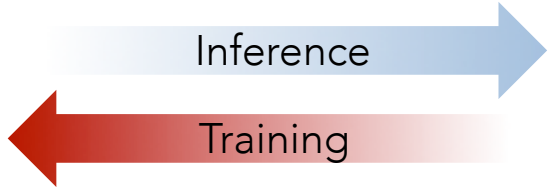
Center for Electronic Materials, Korea Institute of Science and Technology

Discriminative learning generally involves backpropagation and real-valued model parameters



$$u_1 \in R^{28 \times 28}$$

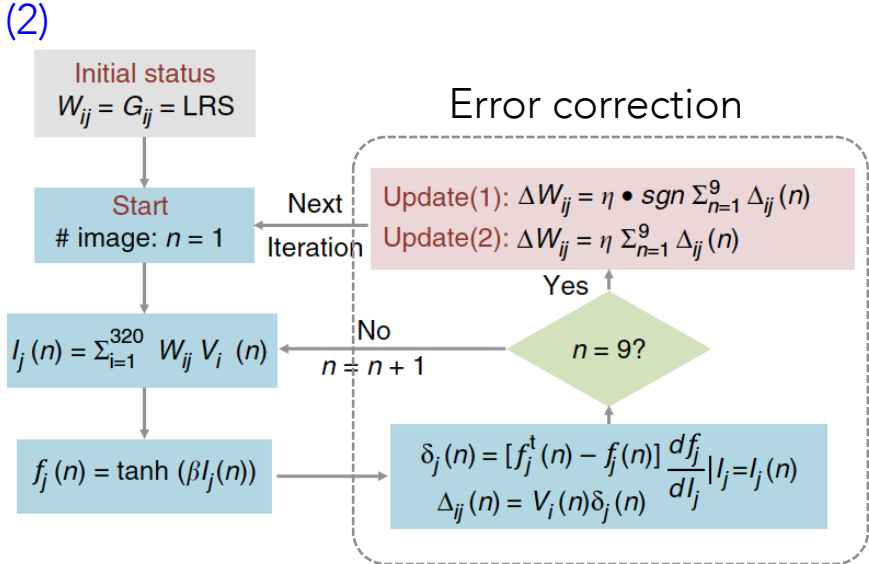
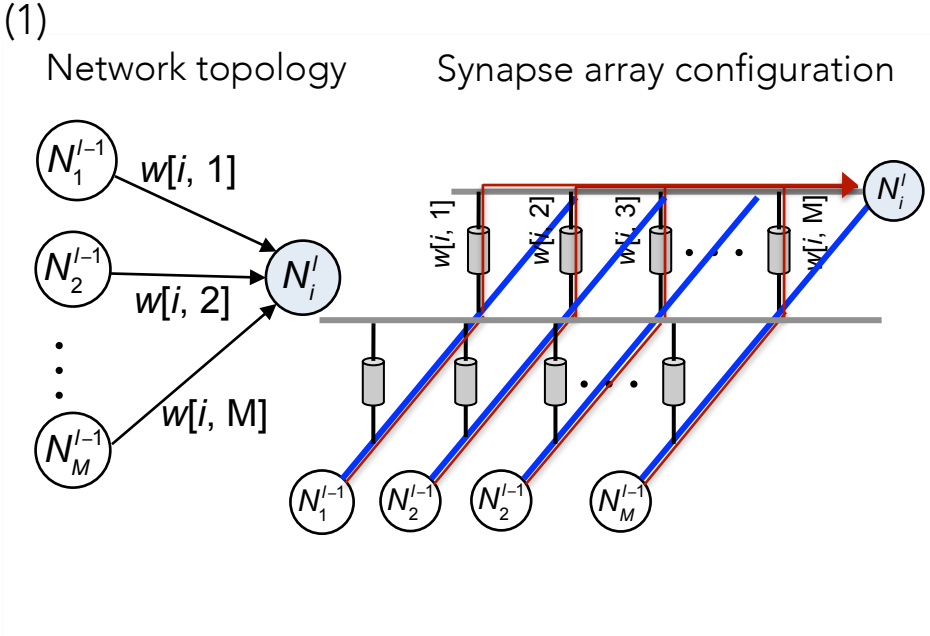
$$N = 10, \text{ i.e. } 0 - 9 \quad u_2 \in R^{10}$$



$$E = f(\vec{a}_{out}, \vec{a}_{Cor}) = f(\vec{a}_{Cor}, w, \vec{b})$$

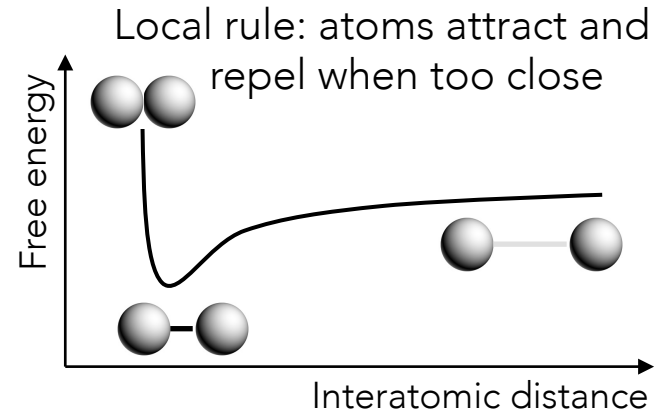
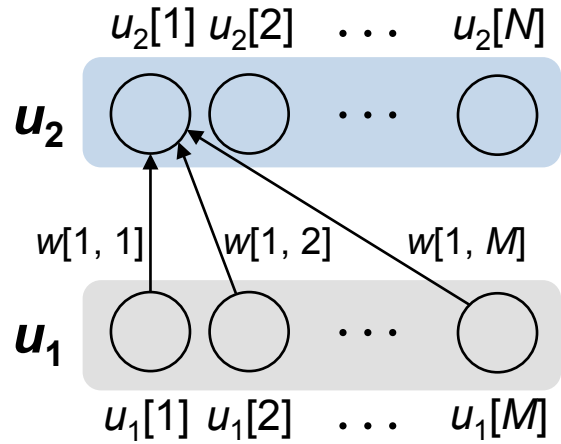
Function of the entire model parameters

Memory-based neuromorphic strategy (1) maps a hypothesis onto a memory array and (2) often applies backpropagation

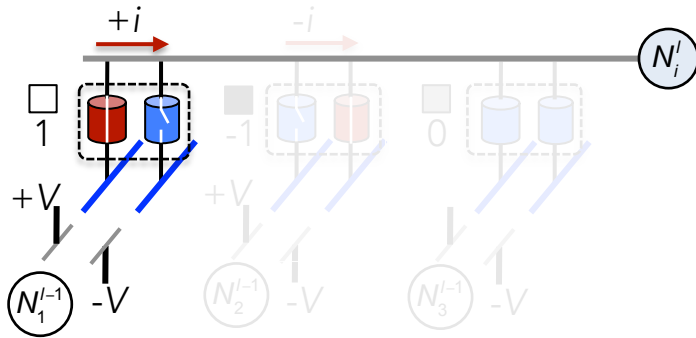


Peng et al., Nat. Commun. 8, 15199 (2017).

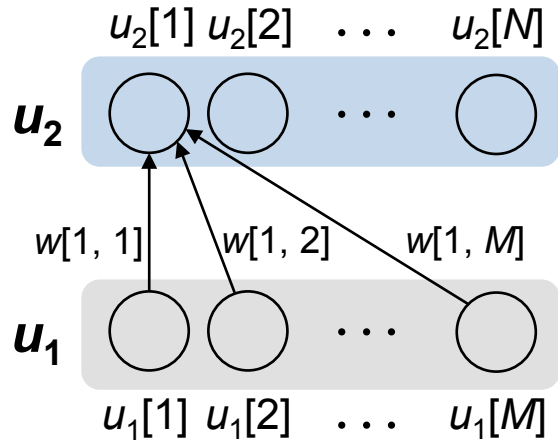
Ternary-weight update using a **local rule** (greedy edge-wise training) may be a workaround for the challenges



$$w[i,j] \in \{-1,0,1\}$$



Markov chain Hebbian learning (MCHL) algorithm

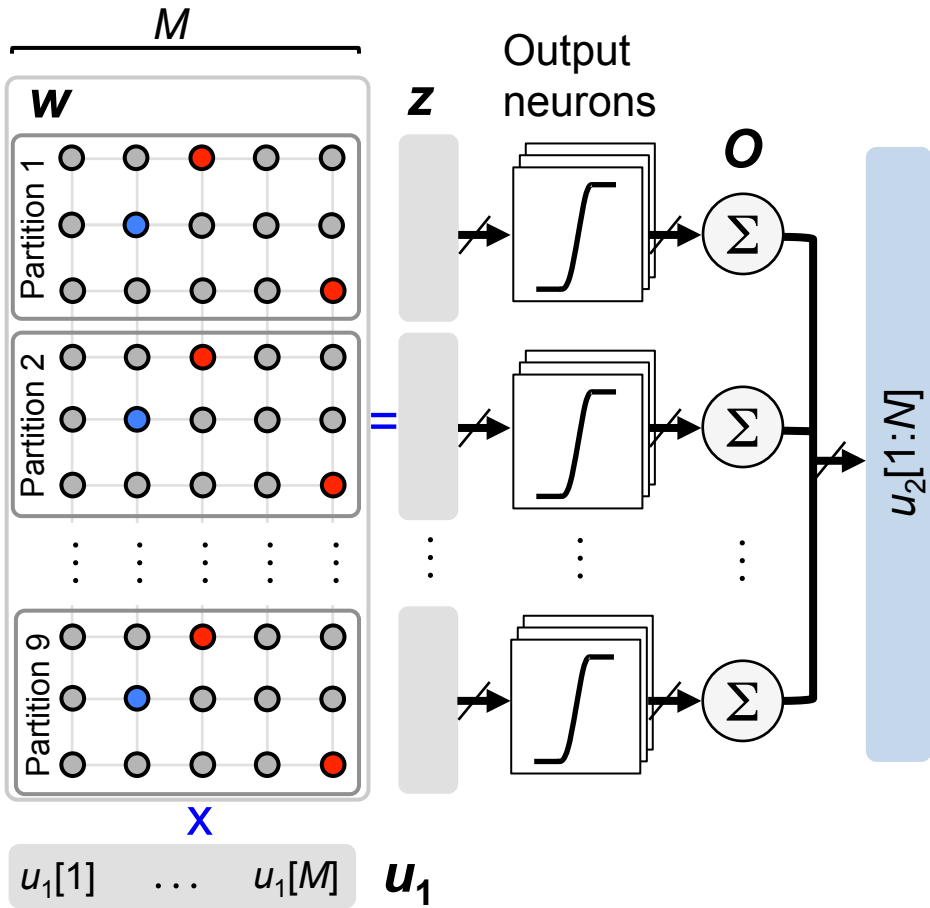


- Greedy edge-wise training
- Discriminative learning by field application towards label space
- Ternary valued weight
- Representation by a group of neurons (cell assembly)

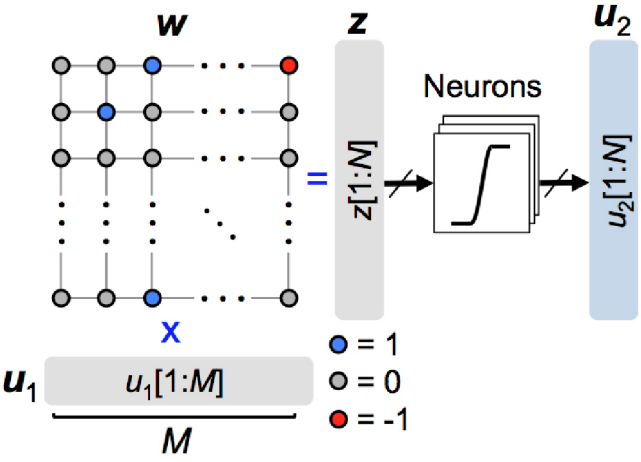
- Model description
- Update method
- Deep network
- Toy example

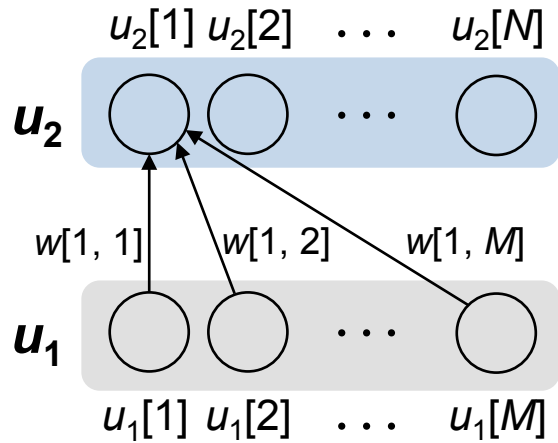
“Markov chain Hebbian learning algorithm with ternary synaptic units” unpublished results

Network includes groups of neurons for associative representation



Cf. group size = 1

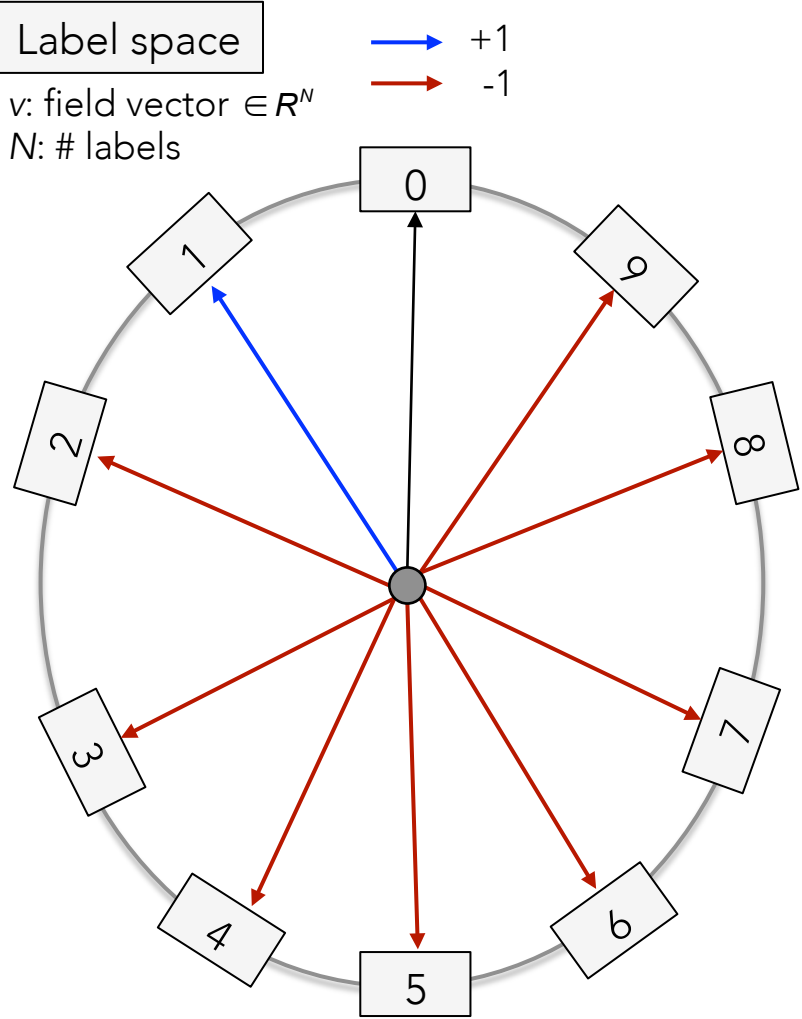




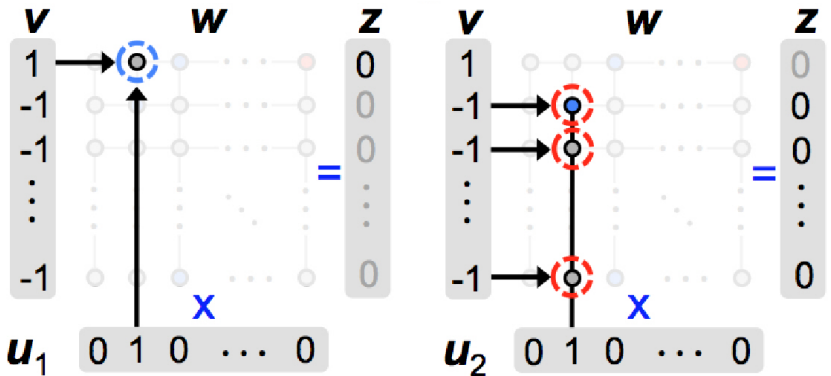
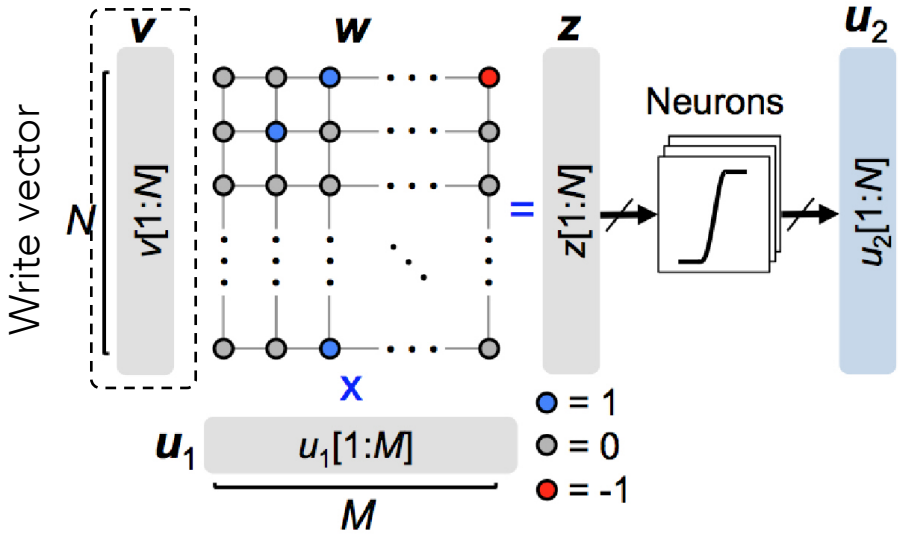
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Supervision is realized by field application in label space

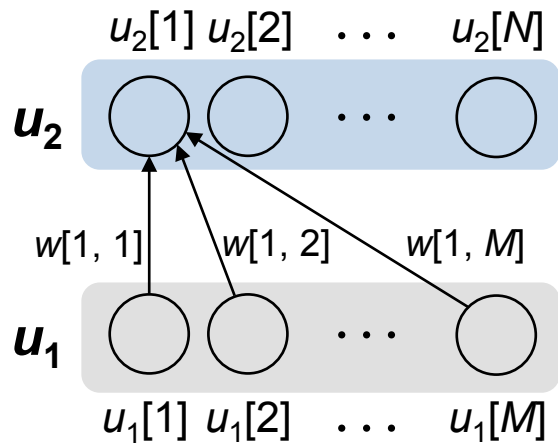


$$v = [-1, 1, -1, \dots, -1]$$



Potentiation

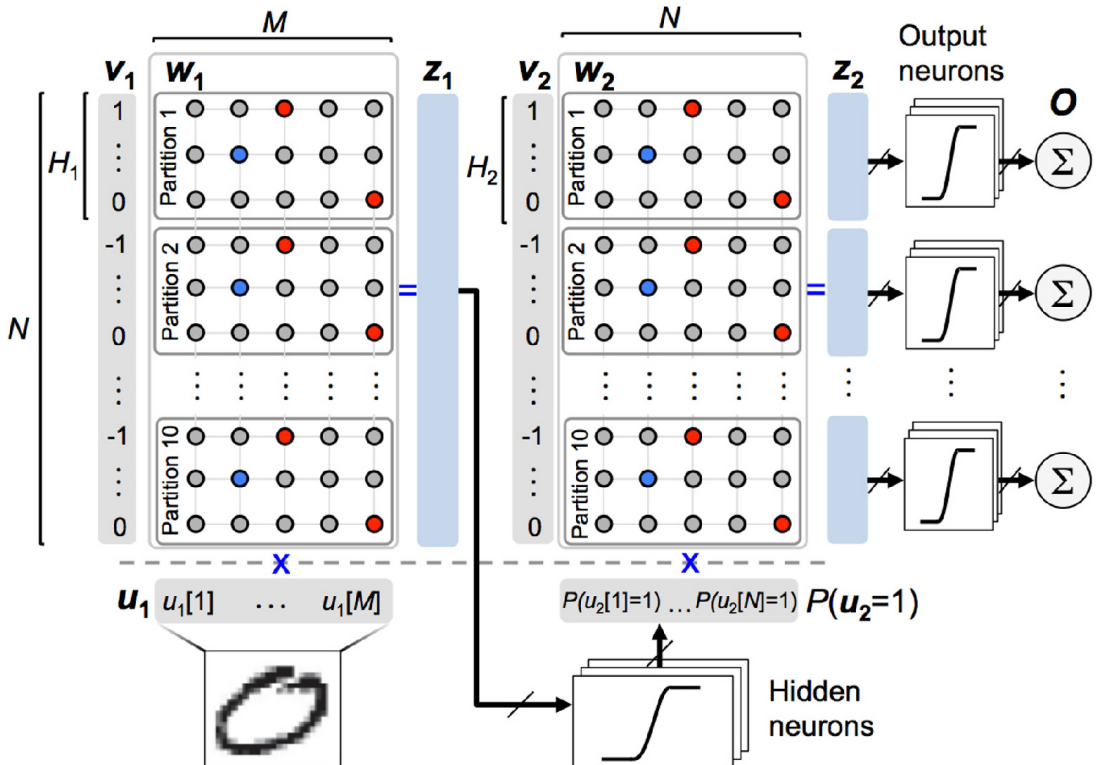
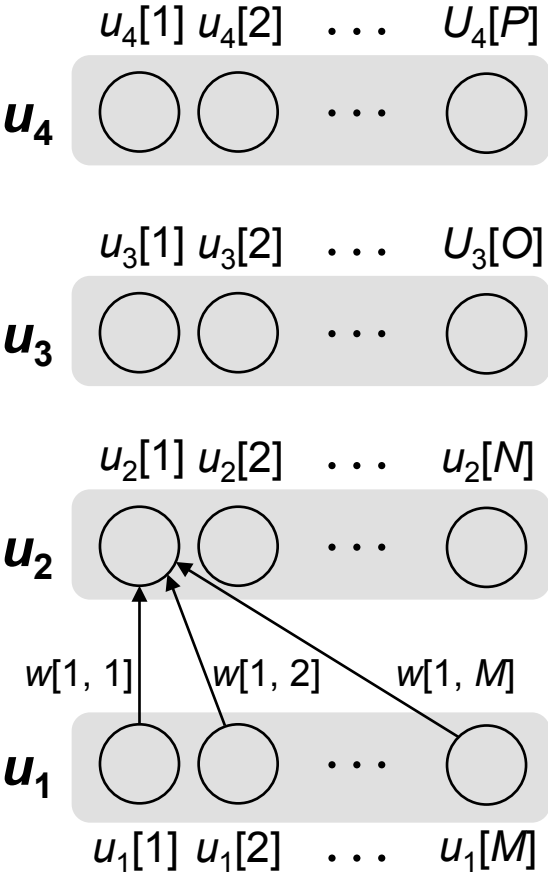
Depression

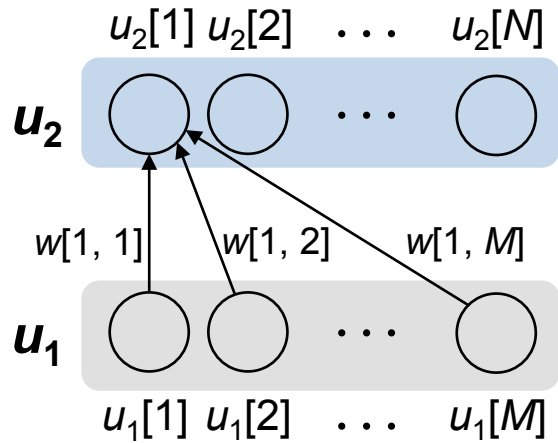


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Deep network is employed and trained in a greedy layer-wise manner

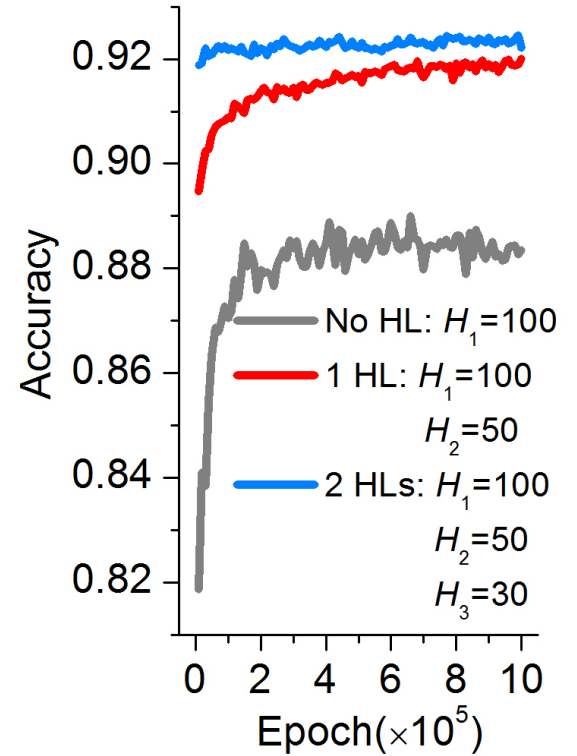
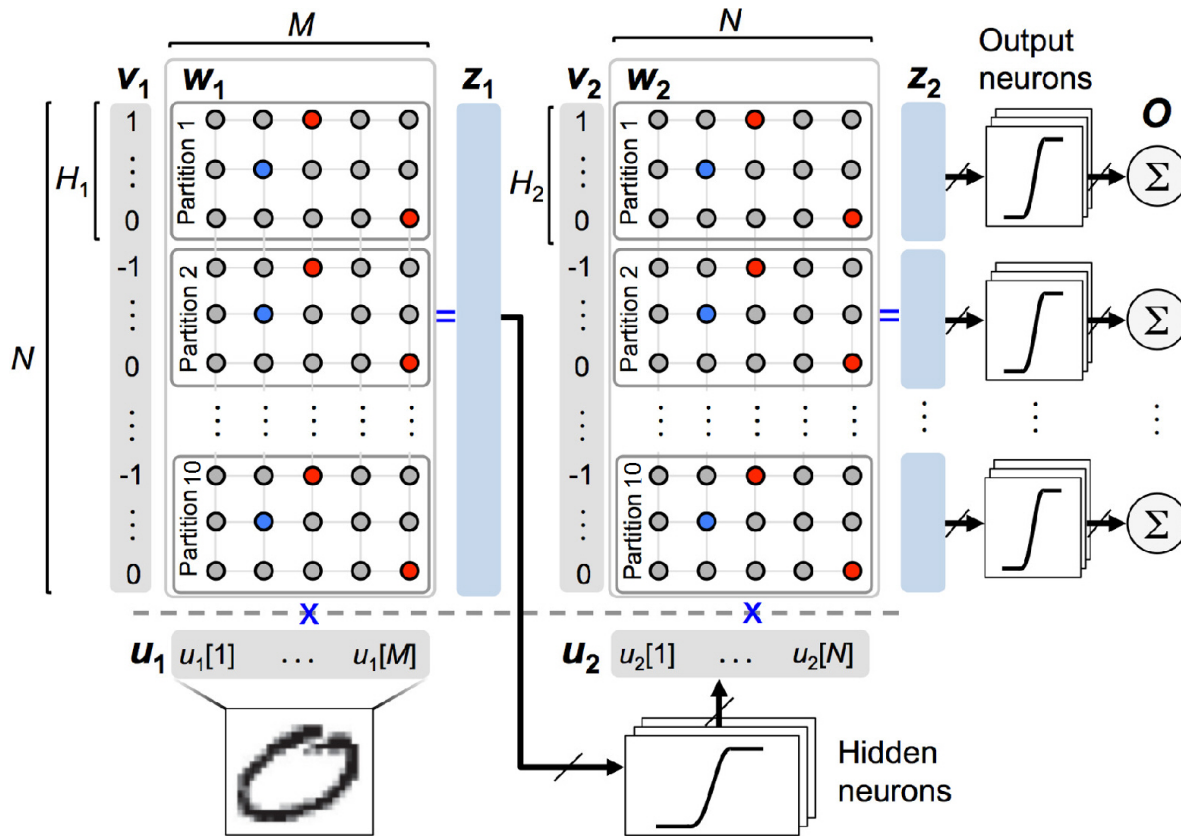




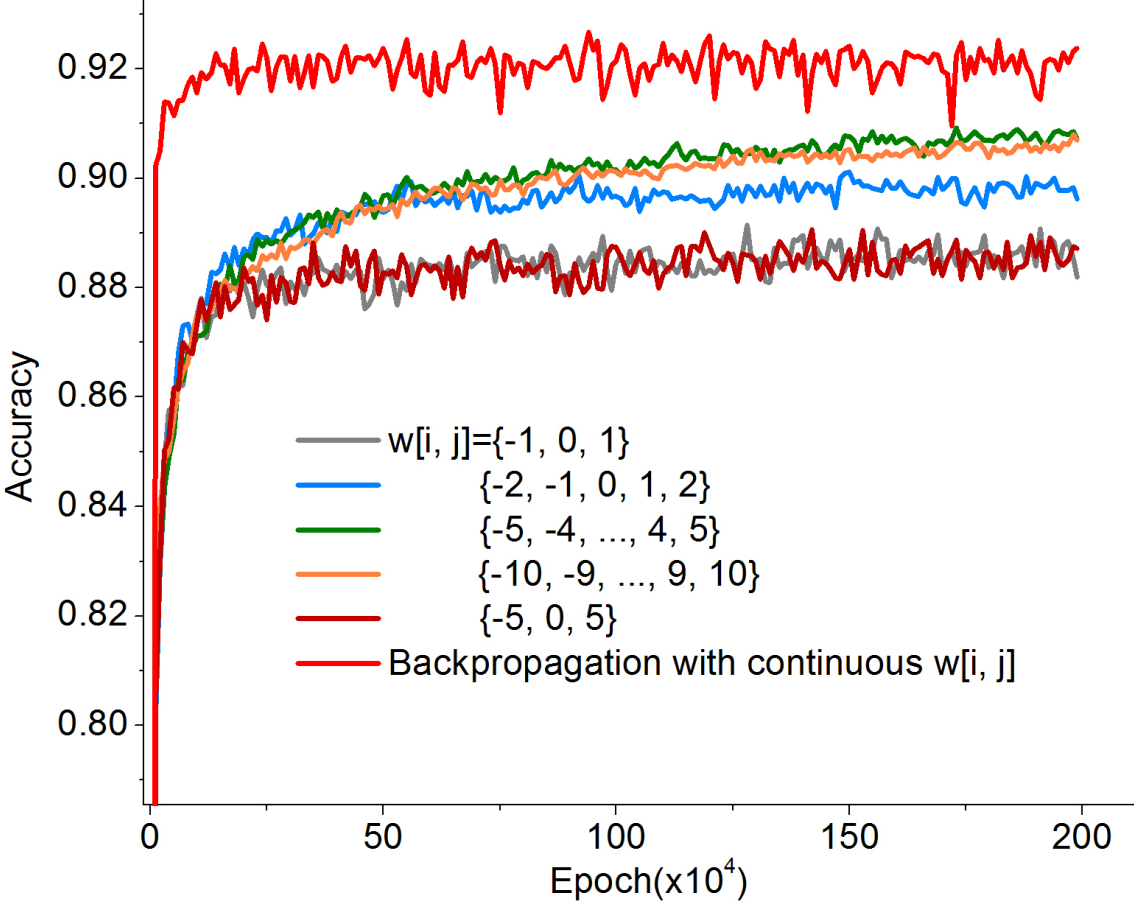
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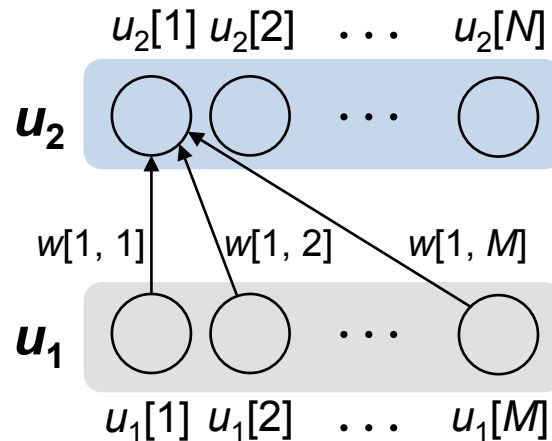
Application to the MNIST dataset learning



Multinary weight improves the recognition accuracy



Markov chain Hebbian learning algorithm



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Thank you!