Tensor network machine learning

Tensor Network Hackathon, Topic 2

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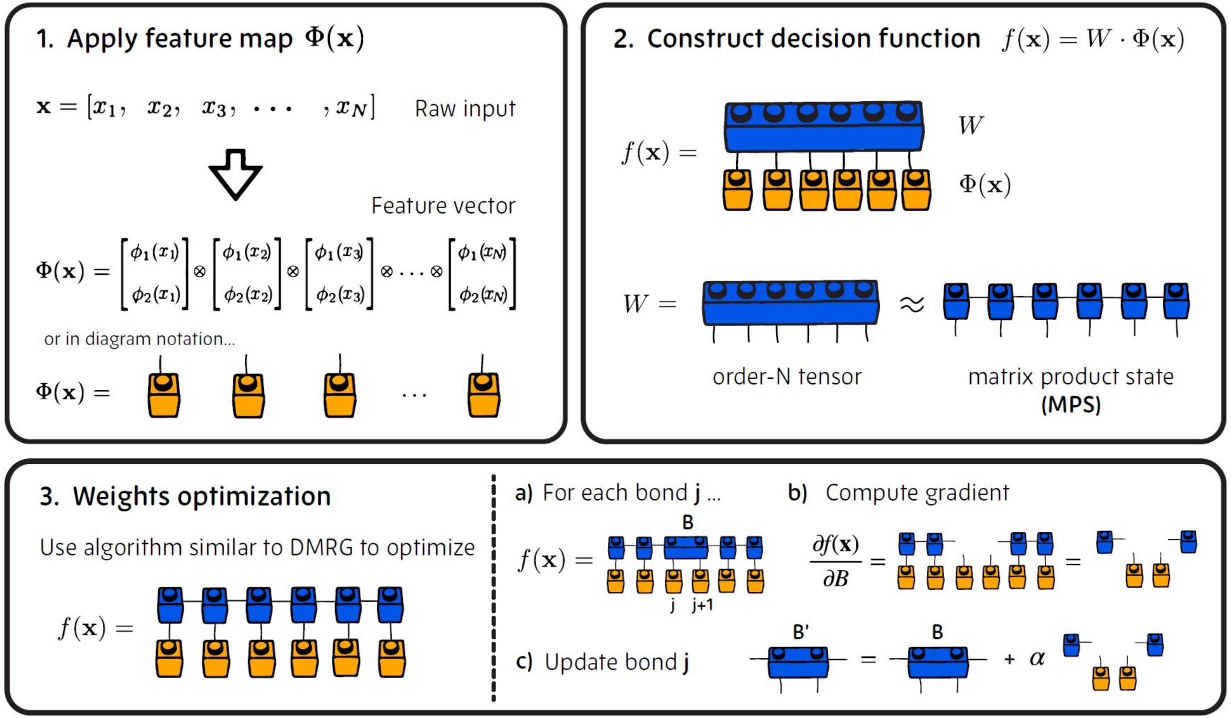
Algorithm implemented in QTEA



Idea from E. Stoudenmire and D. J. Schwab, Advances in neural information processing systems 29 (2016)

Tasks 1 and 2

Classify the digits 3 and 8 of the MNIST dataset using the MPS classifier.

- Encoding 1: $$|q\rangle = \sqrt{1-p_i}\,|0\rangle + p_i\,|1\rangle$$
- Encoding 2: $$|\psi\rangle = \sum_i p_i\,|i\rangle$$

Compare the performances of the two different encodings!

Steps for tasks 1 and 2

1. Load MNIST dataset

2. Build classifier, i.e. convert dataset into a list of MPS

3. Optimize MPS

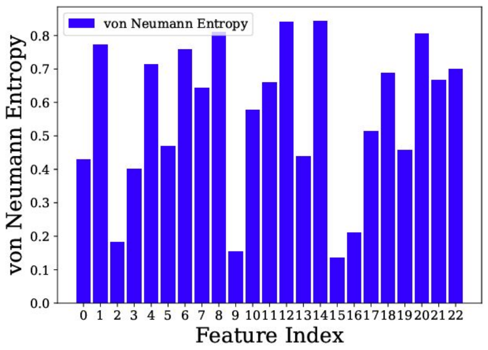
```
svd, loss = tn_classifier.ml_optimize_mps(X_train_mps,
                                          y_train,
                                          batch_size=batch_size,
                                          learning_rate=learning_rate,
                                          num_sweeps=num_sweeps,
                                          n_jobs=1,
                                          verbose=True)
```

4. Get accuracy

```
y_train_pred = tn_classifier.ml_predict(X_train_mps, n_jobs=1)
y_test_pred = tn_classifier.ml_predict(X_test_mps, n_jobs=1)
```

from https://arxiv.org/pdf/2401.00867

Task 3: analyze entanglement



- Analyze entanglement entropy of the bipartitions

- Are you able to understand the important characteristics of your system? Which of the two encodings is better for explainability?

- How does the entanglement entropy and the accuracy vary with the bond dimension?

[optional] Task 4: weight compression with MPS

- Solve the same problem with your favorite neural network
- Following https://arxiv.org/pdf/2305.06058 compress the weights of the neural network
- Which method is better memory-wise? MPS1, MPS2, NN, or MPS-compressed NN?