The Forward Forward Algorithm

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Geoffrey Hinton

Geoffrey Hinton is a British-Canadian computer scientist and psychologist known for his work on **artificial neural networks**. He worked at Google and the University of Toronto from 2013 to 2023.

In 2017, he helped start the **Vector Institute for Artificial Intelligence** in Toronto, where he serves as the chief scientific advisor.

“I have always been convinced that the only way to get artificial intelligence to work is to do the computation in a way similar to the human brain.”

- Geoffrey Hinton

Forward Forward Algorithm

Innovative Training Method: Eliminates traditional backpropagation's forward and backward passes.

Two Forward Passes: Utilizes positive (real) data for the first pass and negative (synthetic) data for the second.

Objective Function per Layer: Maximizes "goodness" for positive data and minimizes it for negative data, using metrics like the sum of squared activities.

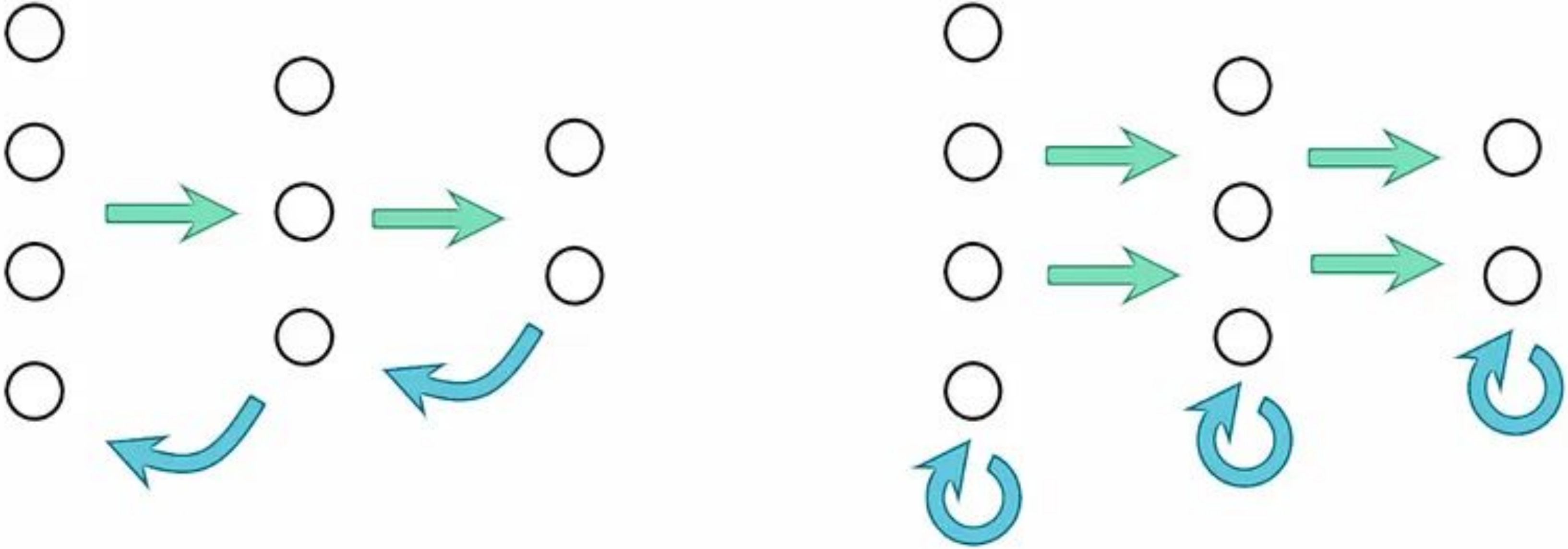
Fordward-Forward Algorithm by Geoffrey Hinton

Backpropagation

Forward → Backward

Forward-Forward

Forward Forward → Local update



Forward-Forward-Forward... vs. Backpropagation

Process: Three forward passes: First for positive data, second for negative data, and a hypothetical third for additional refinement or error correction without backward propagation.

Computation: Each layer's objective is to improve based on "goodness" metrics, potentially reducing the need for gradient computation.

Process: Involves a forward pass to compute the output and a backward pass to adjust weights based on error gradients.

Computation: Relies on gradient descent to minimize error, requiring storage and computation of gradients.

Forward-Forward-Forward… vs. Backpropagation

Biological Plausibility: Potentially more aligned with natural neural processes, as it avoids the non-biological backward pass.

Efficiency: Could offer computational advantages by eliminating the need for backpropagation and allowing offline processing for parts of the learning.

Biological Plausibility: Lacks a direct counterpart in biological neural systems due to the backward pass.

Efficiency: Can be computationally intensive, especially for deep networks with large datasets.

Why did I choose the CIFAR-10 data set?

Diverse Images: CIFAR-10 provides 60,000 color images across 10 categories, offering a wide variety of patterns for comprehensive learning.

Real-World Complexity: Unlike simpler, monochromatic datasets, CIFAR-10's color images better mimic the complexity of real-world visual data.

Testing on CIFAR-10 dataset :(

```
"C:\Users\Angi\Desktop\Anul 3\Semestrul 1\Arheologie\venv\Scripts\python.exe" "C:\Users\Angi\Desktop\Anul 3\Semestr
Files already downloaded and verified
Files already downloaded and verified
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
training layer 0 ...
100%|██████████| 1000/1000 [1:51:25<00:00,  6.69s/it]
training layer 1 ...
100%|██████████| 1000/1000 [28:25<00:00,  1.71s/it]

Process finished with exit code -1073741819 (0xC0000005)
```

Testing on Fashion-MNIST dataset

```
training layer 0 ...
100%|██████████| 1000/1000 [56:10<00:00,  3.37s/it]
training layer 1 ...
100%|██████████| 1000/1000 [29:43<00:00,  1.78s/it]
train error: 0.16763997077941895
test error: 0.18040001392364502
```

Conclusion

Revolutionizing traditional training methods, the **Forward-Forward Algorithm** demonstrates remarkable efficiency on the MNIST and Fashion-MNIST dataset. Future research aims at scaling for larger datasets, optimizing negative data handling, and exploring biological plausibility. As capabilities expand, the algorithm offers new insights into AI and our understanding of biological learning processes.

Thanks!