
2023-1 YBIGTA-Science Reading Group

The Forward-Forward Algorithm: Some Preliminary Investigations

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Table of Content

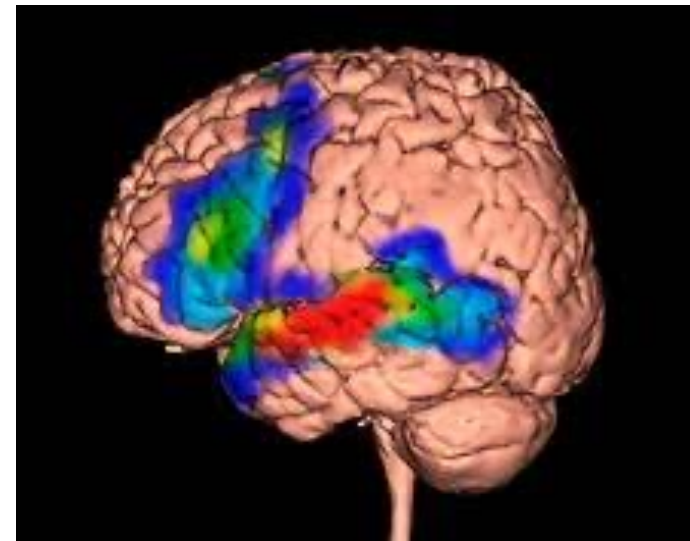
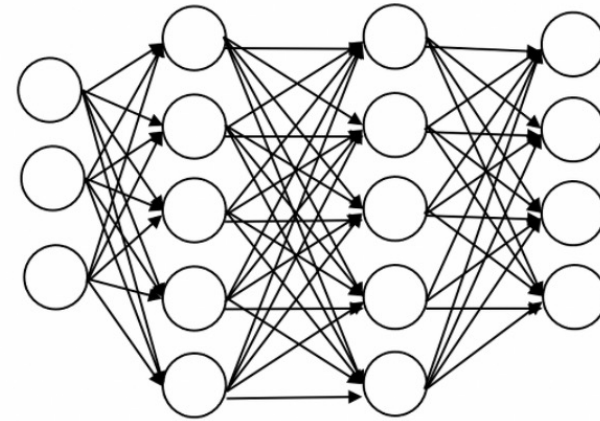


- Overview
- Limitations of Backpropagation
- The Forward-Forward Algorithm
- Experiments
- Future work

Overview



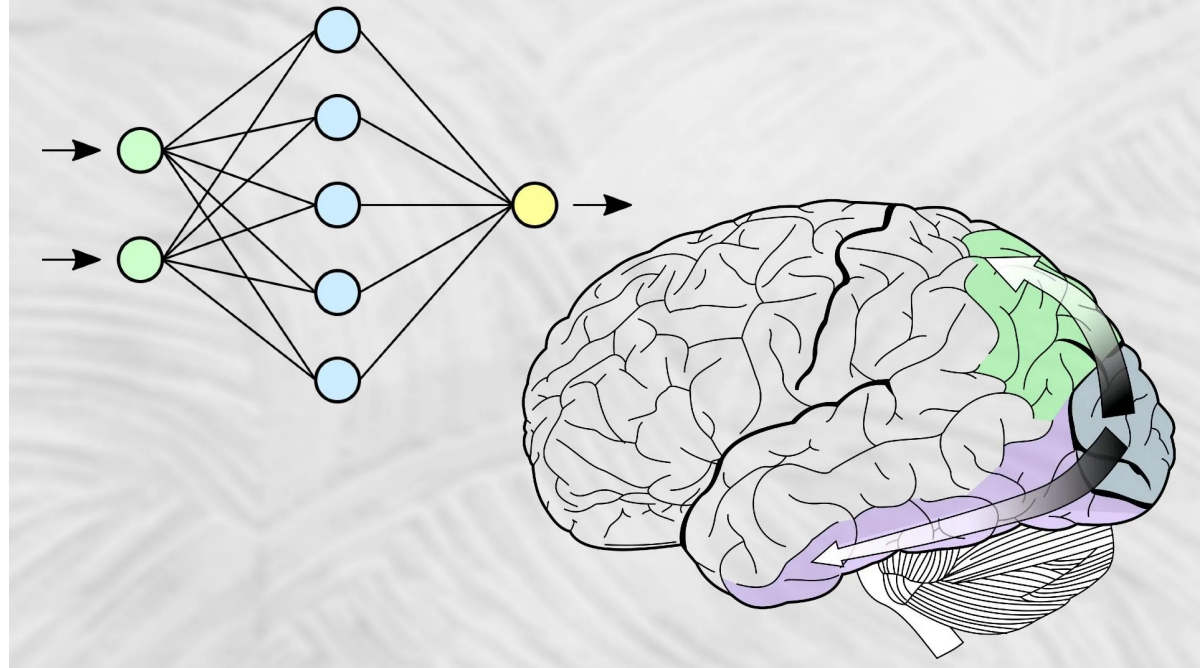
- Geoffrey Hinton
 - Backpropagation, AlexNet ...
- Human Brain
 - Cortex
 - Actually, No Backpropagation



Limitations of Backpropagation



- What if NOT Differentiable
- Learning and Inference don't progress simultaneously



The Forward-Forward Algorithm



- Inspired by Boltzmann machines & Noise Contrastive Estimation
- Unit(layer) 단위로 Local weight update

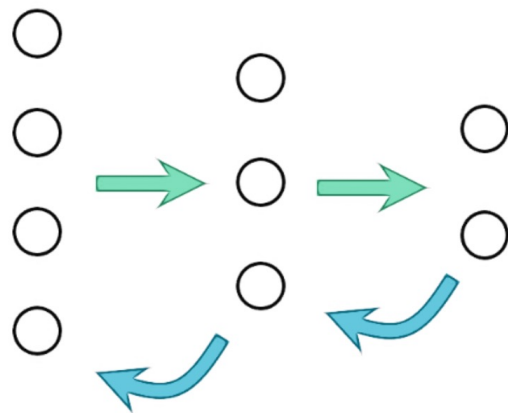
- Two forward passes

- Positive pass
- Negative pass
- Goodness

Forward-Forward Algorithm by Geoffrey Hinton

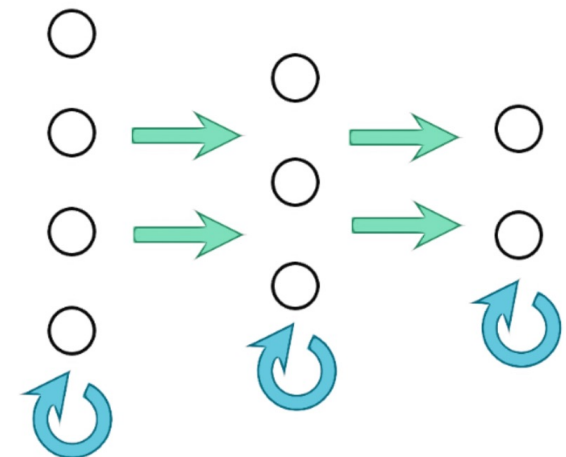
Backpropagation

Forward → Backward



Forward-Forward

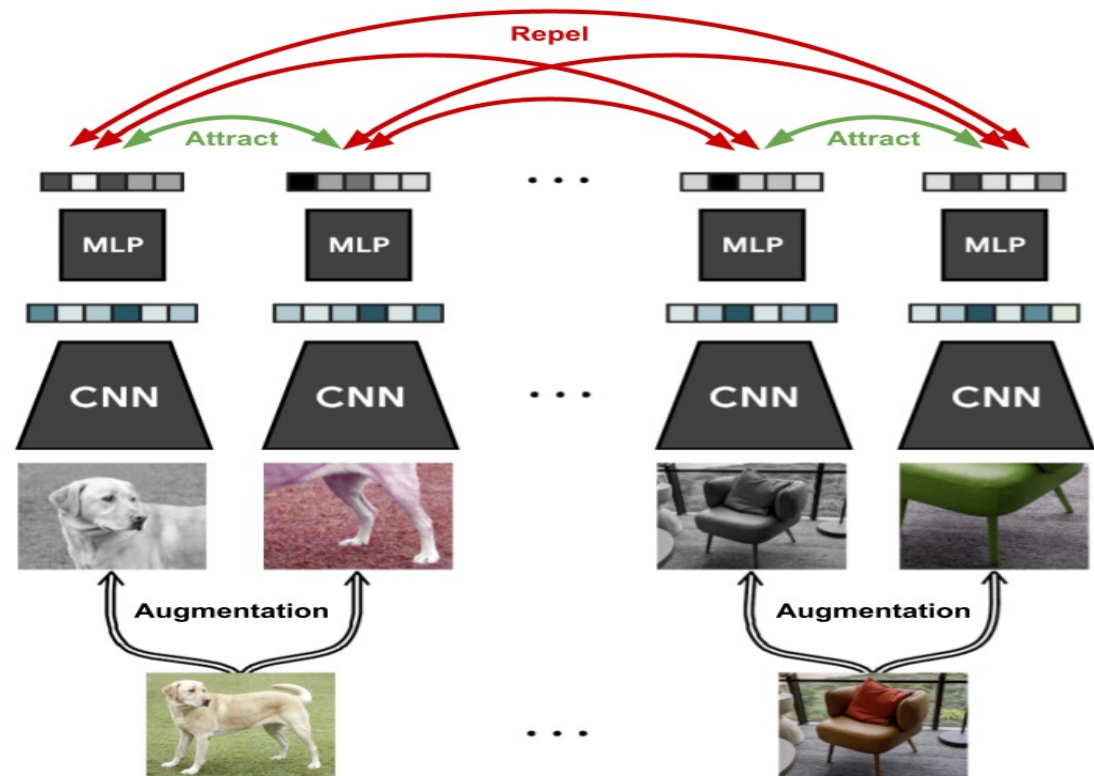
Forward Forward → Local update



The Forward-Forward Algorithm



- Contrastive Representation Learning (CRL)
- 입력 샘플 간의 비교를 통한 표현 학습
 - 비슷한 데이터는 '가깝게'
 - 다른 데이터는 '멀게'



The Forward-Forward Algorithm



- Positive Pass : Positive data에 가깝게
- Negative Pass : Negative data에 멀어지게
- Goodness 값을 보고 Positive or Negative

EX) Goodness = SSE

$$p(\text{positive}) = \sigma \left(\sum_j y_j^2 - \theta \right)$$

Experiments



- MNIST Dataset
 - CNN(Backpropagation) : 0.6% error
 - Forward-Forward : 1.4% error
- Unsupervised Learning
 - 좋은 negative data는 어떻게 얻을 것인가

Experiments



- Negative data(False data)
 - A random mask consisting of 0 and 1 is created in Positive data and multiplied by each pixel
 - Create an inverted mask with the value of $(1-\text{mask})$ and multiply it by the Negative data
 - Add two images together and create hybrid images

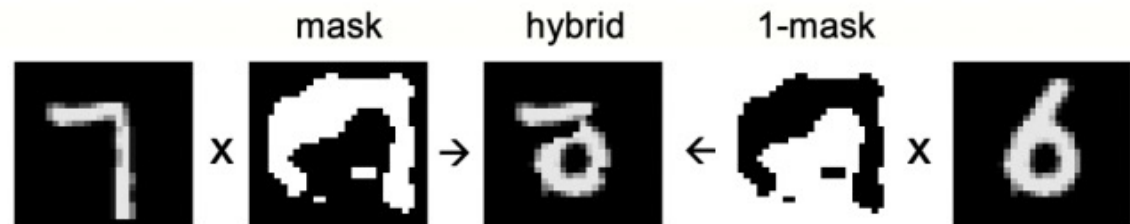


Figure 1: A hybrid image used as negative data

- 4 FC layers, 100 epochs : 1.37% error

The Forward-Forward Algorithm



- Feed-Forward
 - Not being able to update the training information of a later layer to the previous layer
- Treat images like a video!
 - Video data where the same image is repeated
- Multi layer RNN (Geoffrey Hinton, 2022)

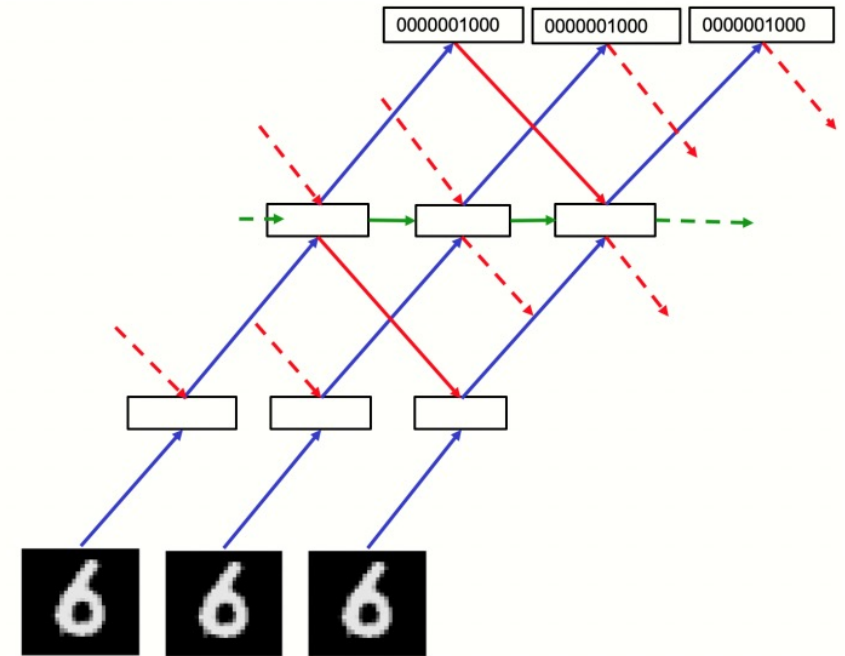


Figure 3: The recurrent network used to process video.

Future work



- Efficient in Low Power situations, But..
- Can FF produce a generative model of images or video that is good enough to create the negative data needed for unsupervised learning?
- What is the best goodness function to use?
- What is the best activation function to use? So far, only ReLUs have been explored.

Thank You

