Swarm Learning - A Fully Decentralised Approach To Machine Learning

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Why Distributed Machine Learning

The Problems

Privacy

- Data stored in multiple locations
- Cannot share the data between locations for privacy reasons
- *Medical records*

Performance

- Machine learning needs lots of processing power
- A supercomputer is not available to many
- However they may have access to many lower power devices (nodes)
- *Company with many unused computers during the night*

Federated Learning

Federated Learning - The Current Solution

- A single model is stored on the server
- Server controls many nodes - computers that can perform training
- Each node has its own dataset
    - This is not shared with other nodes or the server
- **Goal:** Perform machine learning by only sharing the model, not the data

Federated Learning - Variations

- Many variations of federated learning
  - One of the originals is *Federated Averaging (FedAvg)*
  - Many other algorithms are based off this

Federated Learning - How Does It Work?

- FedAvg has repeated training steps. Each step:
    1. Server sends model to a set of nodes
    2. Nodes perform training on the model
    3. Nodes send their models back to server
    4. New model is the average (mean) of all nodes models

Federated Learning - Issues

- Vulnerable to central server going down
- Requires that every node has direct access to the server
- Few slow nodes slow the whole process down

Swarm Learning

Swarm Learning

- No central server/node
- Each node has a distinct model, called the *local model*
    - Must keep all local models close to each other
- Each node has its own dataset
    - This dataset cannot be shared with any other nodes
- The goal is to train all local models using all available data

Swarm Learning - How Does It Work?

- Repeated Training Steps. Each node each step:
    1. Perform training on the local model
    2. Send trained model to all neighbours
        - This will get saved on the neighbour
    3. New local model is the combination of all neighbours most recent local models

Swarm Learning - Specifics

- Different combination methods
  - Combine by average
  - Combine with learning rate
- Only combine neighbours who have done more training than this node
- Wait for certain number of neighbours to catch up with this node

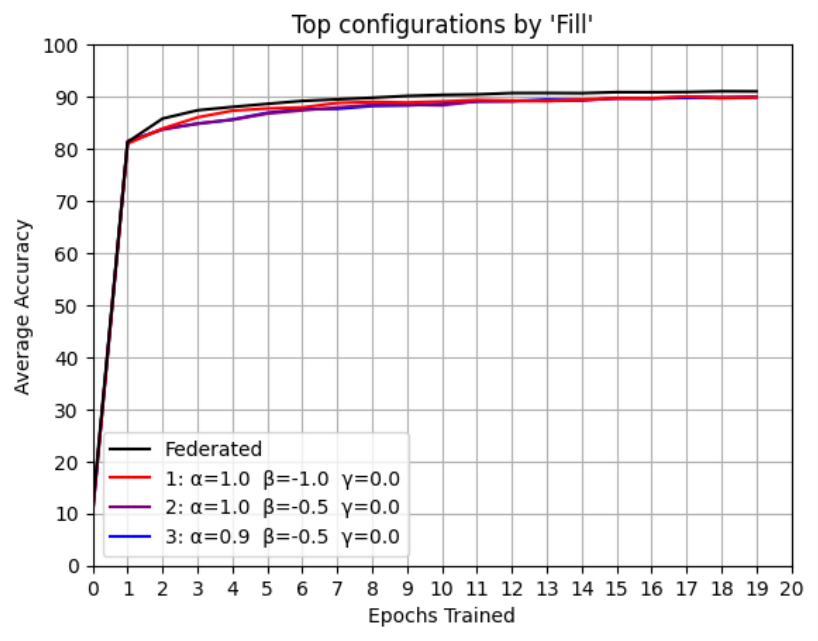
Swarm Learning vs Issues of Federated Learning

- ~~Vulnerable to central server going down~~
  - No central server - to stop training you would have to take out every node
- ~~Requires that every node has direct access to the server~~
  - Swarm learning can function on sparse networks of nodes
- ~~Few slow nodes slow the whole process down~~
  - You never have to wait for a node to communicate, instead use the most recent model it sent

Results

Swarm Learning - Performance

- Following plots are *accuracy* of classifying MNIST Fashion, and x axis is number of epochs trained
  - To make the problem a little harder each node only has 10 percent of the dataset
- Many different configurations of the algorithm, can drastically affect performance
  - In following plots only top 3 configurations sorted by a specific metric
  - For example metric might be 'area under graph'
- Following plots nodes are densely connected


Top configurations by 'Fill'
Average Accuracy
Epochs Trained
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
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7
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11
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14
15
16
17
18
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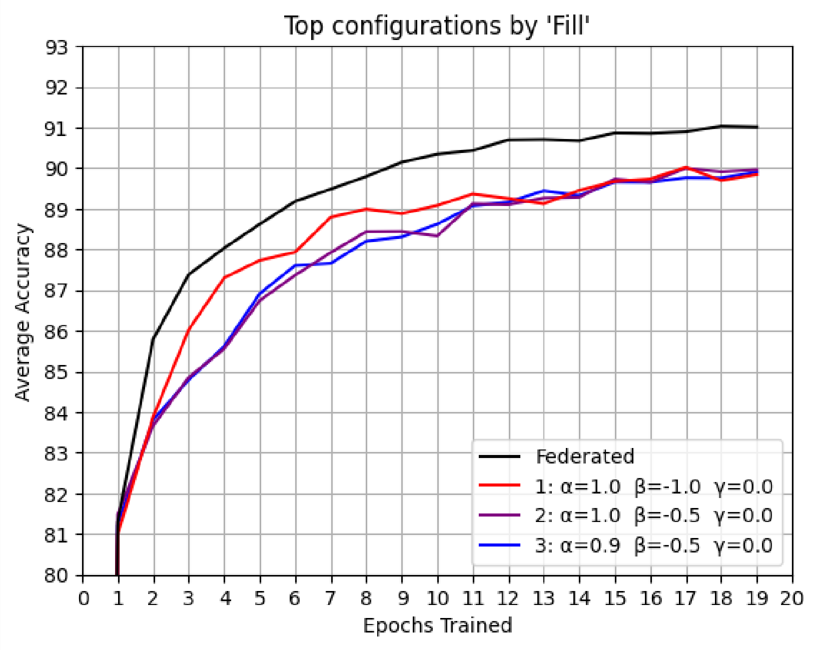
20
Federated
1: α=1.0 β=-1.0 γ=0.0
2: α=1.0 β=-0.5 γ=0.0
3: α=0.9 β=-0.5 γ=0.0


Top configurations by 'Fill'
Average Accuracy
80
81
82
83
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Epochs Trained
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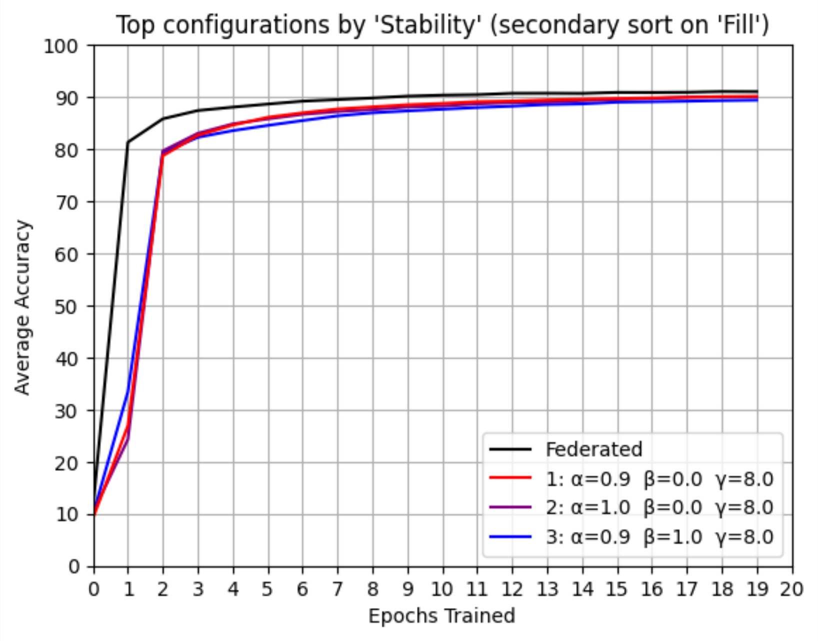
Top configurations by 'Stability' (secondary sort on 'Fill')
Average Accuracy
0
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20
30
40
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100
Epochs Trained
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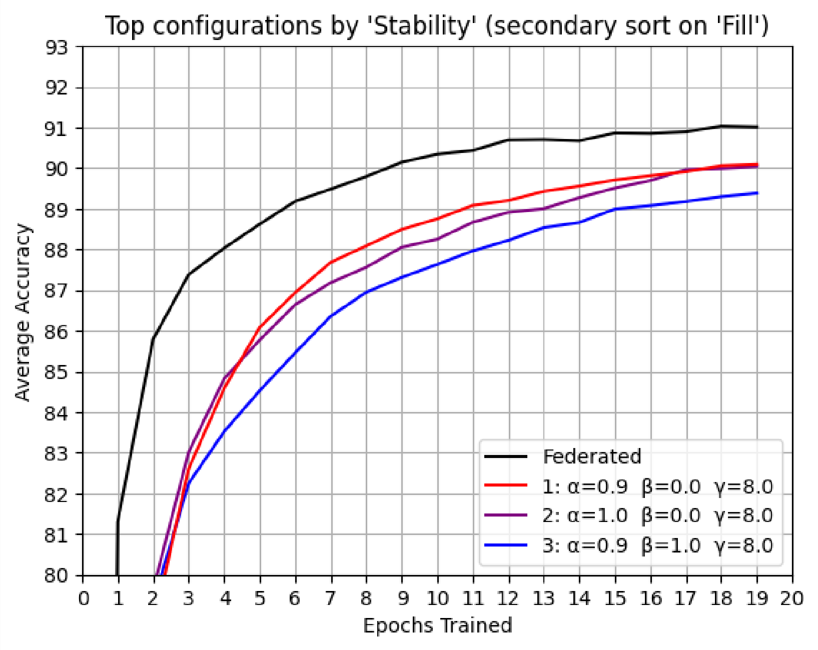
Federated
1: α=0.9 β=0.0 γ=8.0
2: α=1.0 β=0.0 γ=8.0
3: α=0.9 β=1.0 γ=8.0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Conclusion

- Swarm Learning is a promising machine learning algorithm for training a model on data distributed on private data islands
- It addresses some of the issues with Federated Averaging, one of the current techniques
- It does not perform quite as well as Federated Averaging in a densely connected network

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Thanks for listening!

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